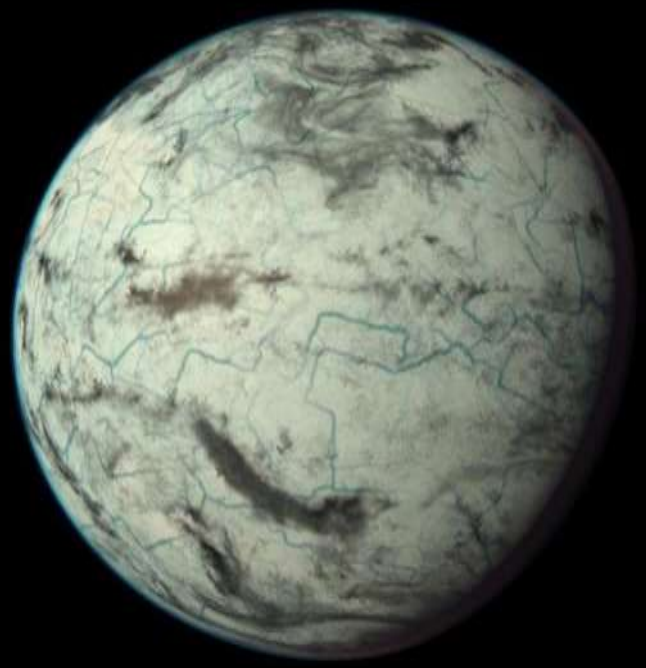
CARMENES: ¿Existen otras Tierras en nuestra Galaxia?



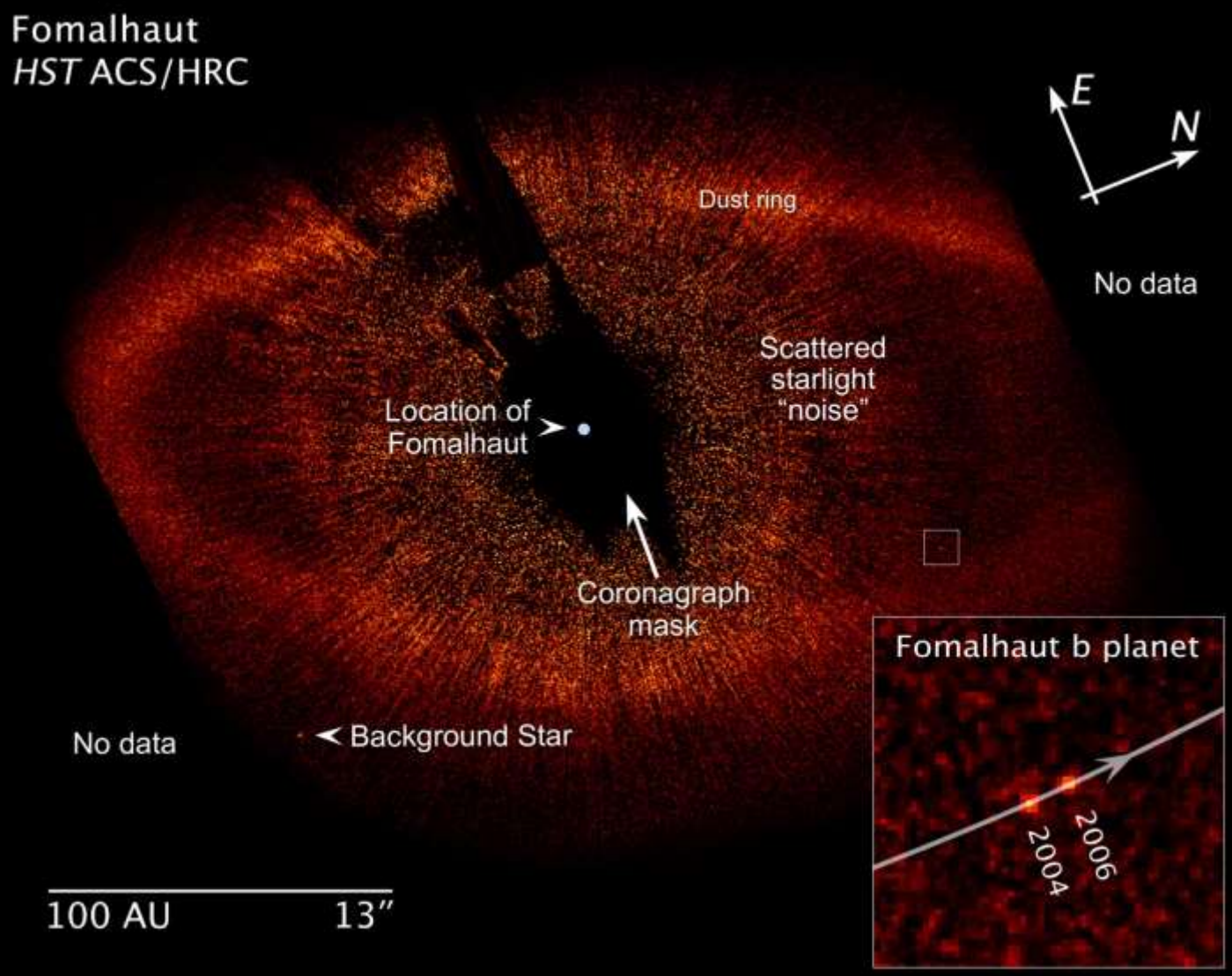
Pedro J. Amado González
Instituto de Astrofísica de Andalucía (IAA-CSIC)

CREDIT: PHL @ UPR Arecibo

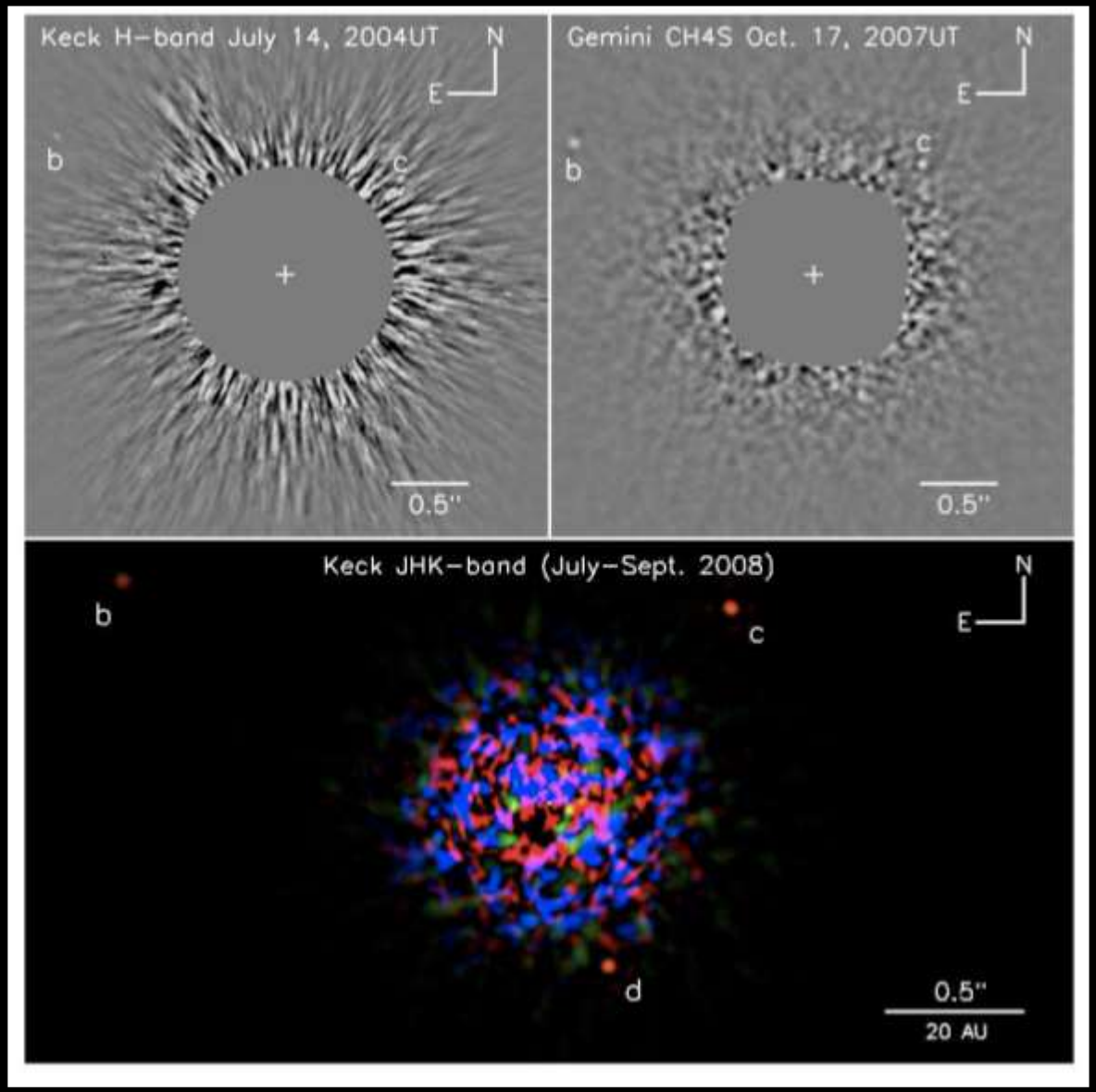
Fotos de planetas

Credit: NASA, ESA, and The Hubble Heritage Team (STScI/AURA)

Fotos de exoplanetas



Fotos de exoplanetas



Fotos de exoplanetas

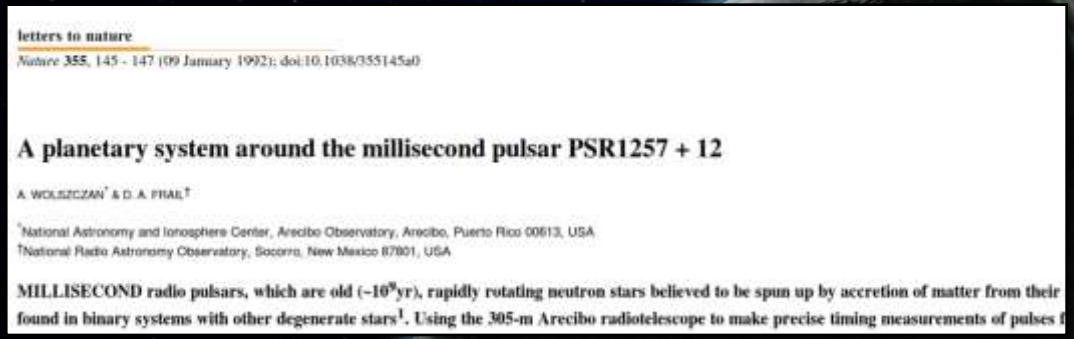
Conceptos

Exoplaneta:

Planeta que orbita una estrella diferente al Sol y que, por tanto, no pertenece a nuestro Sistema Solar

La revolución de los exoplanetas

1992: el primero, primero



letters to nature

Nature **355**, 145 - 147 (09 January 1992); doi:10.1038/355145a0

A planetary system around the millisecond pulsar PSR1257 + 12

A. WOLSZCZAN* & D. A. FRAIL†

*National Astronomy and Ionosphere Center, Arecibo Observatory, Arecibo, Puerto Rico 00613, USA
†National Radio Astronomy Observatory, Socorro, New Mexico 87801, USA

MILLISECOND radio pulsars, which are old (~10^9yr), rapidly rotating neutron stars believed to be spun up by accretion of matter from their found in binary systems with other degenerate stars[1]. Using the 305-m Arecibo radiotelescope to make precise timing measurements of pulses f

Crédito imagen: NASA/JPL-Caltech/R. Hurt (SSC)

La revolución de los exoplanetas

1995: el primero

article

Nature **378**, 355 - 359 (23 November 1995); doi:10.1038/378355a0

A Jupiter-mass companion to a solar-type star

MICHEL MAYOR & DIDIER QUELOZ

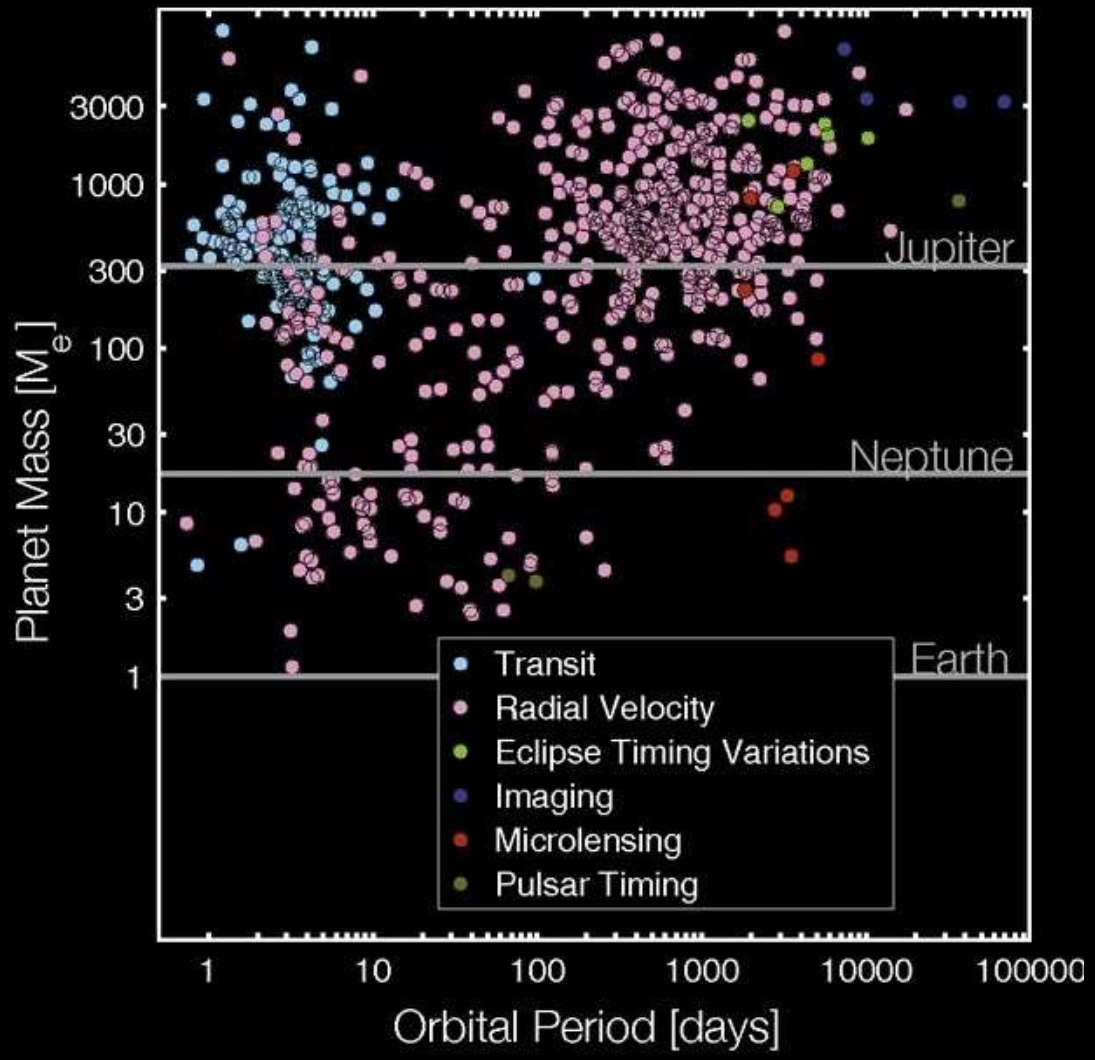
Geneva Observatory, 51 Chemin des Maillettes, CH-1290 Sauverny, Switzerland

The presence of a Jupiter-mass companion to the star 51 Pegasi is inferred from observations of periodic variations in the star's r
eight million kilometres from the star, which would be well inside the orbit of Mercury in our Solar System. This object might be a

Crédito imagen: Debivort de en.wikipedia.org

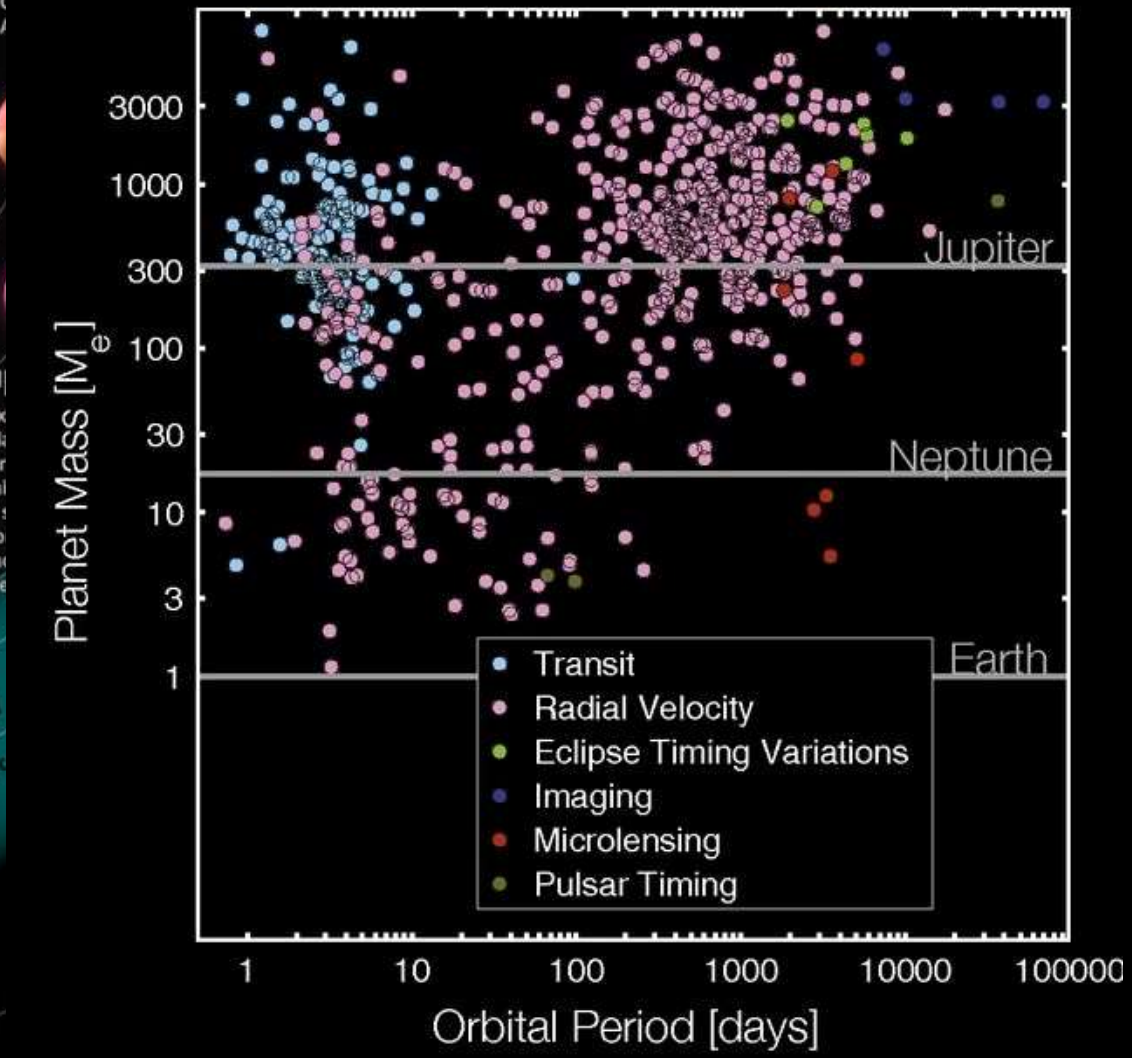
La revolución de los exoplanetas

de 4 a 3500 en 21 años



La revolución de los exoplanetas

de 4 a 3500 en 21 años



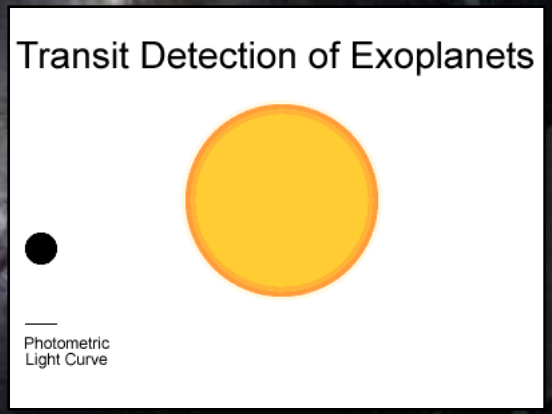
La revolución de los exoplanetas

La misión Kepler (2009-2013)

30/05/2016

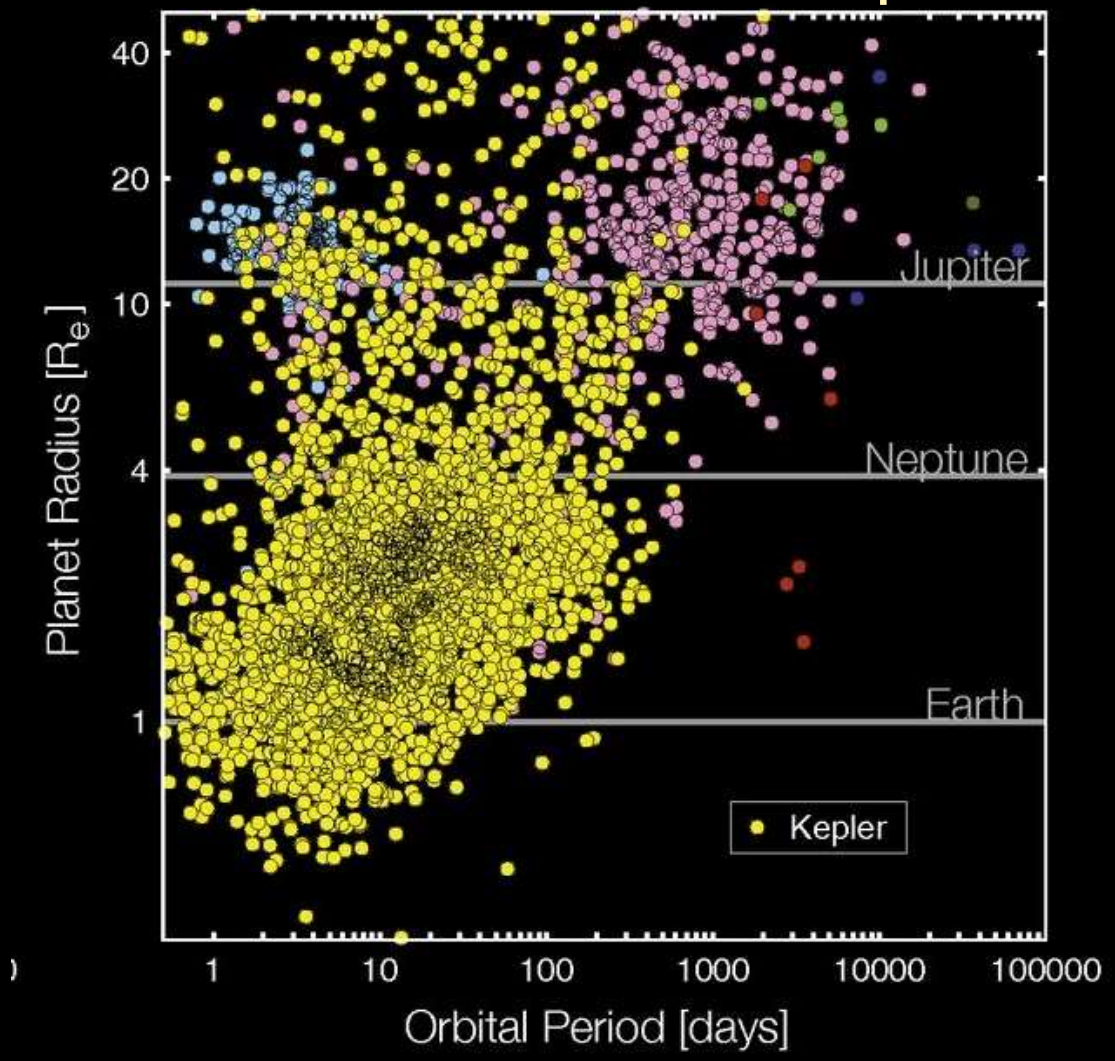
Planetas Verificados: 2327
Planetas Candidatos: 4706

Método de los tránsitos
R_p/R_*
Inclinación i
Tamaño de la órbita a



La revolución de los exoplanetas

Planetas de todo tipo



Más de 3500 planetas verificados o confirmados

Conceptos

Exoplaneta:

Planeta que orbita una estrella diferente al Sol y que, por tanto, no pertenece a nuestro Sistema Solar

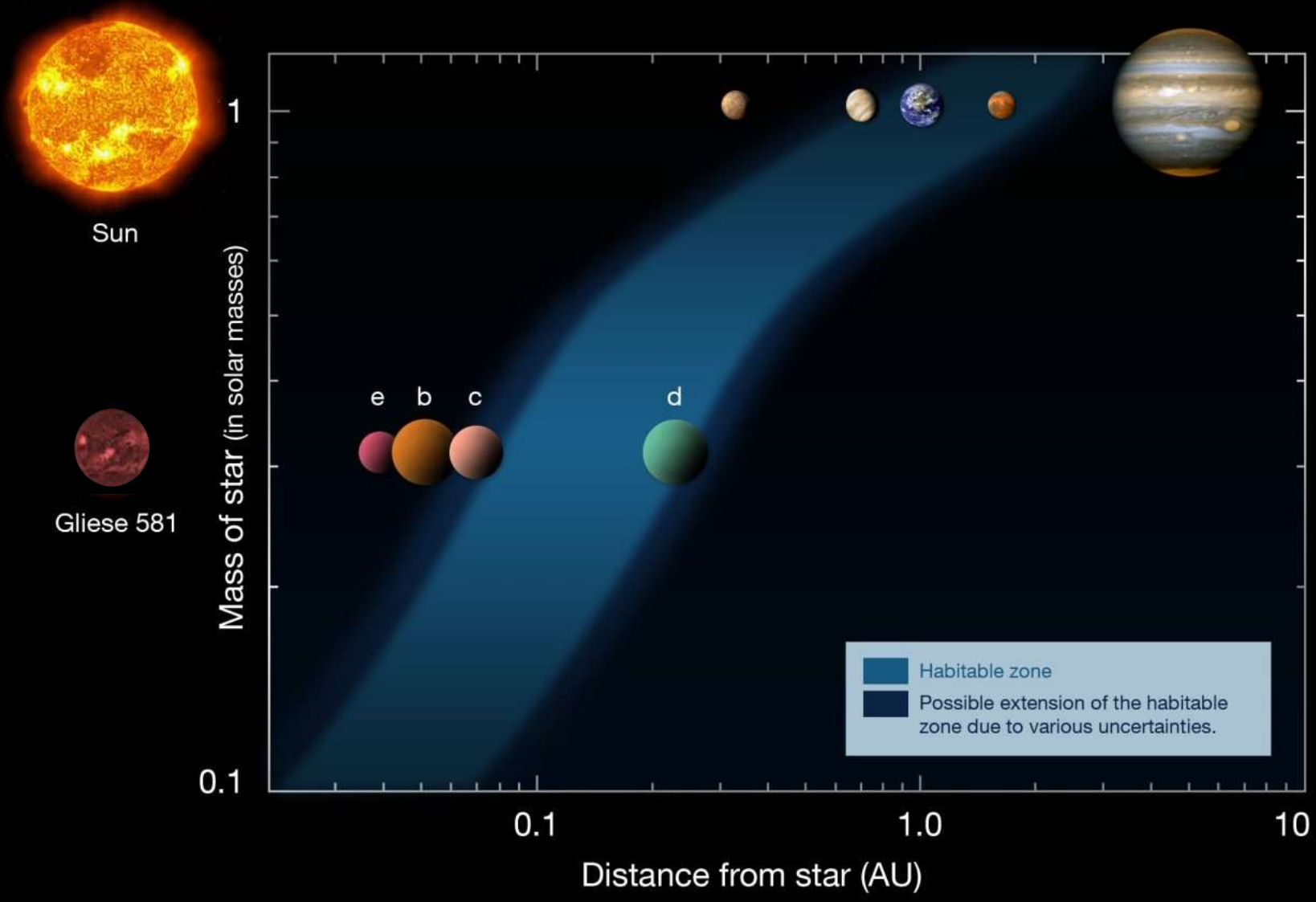
Zona habitable:

Distancia a la que orbita un exoplaneta de su estrella que permite temperatura adecuada para agua líquida en la superficie

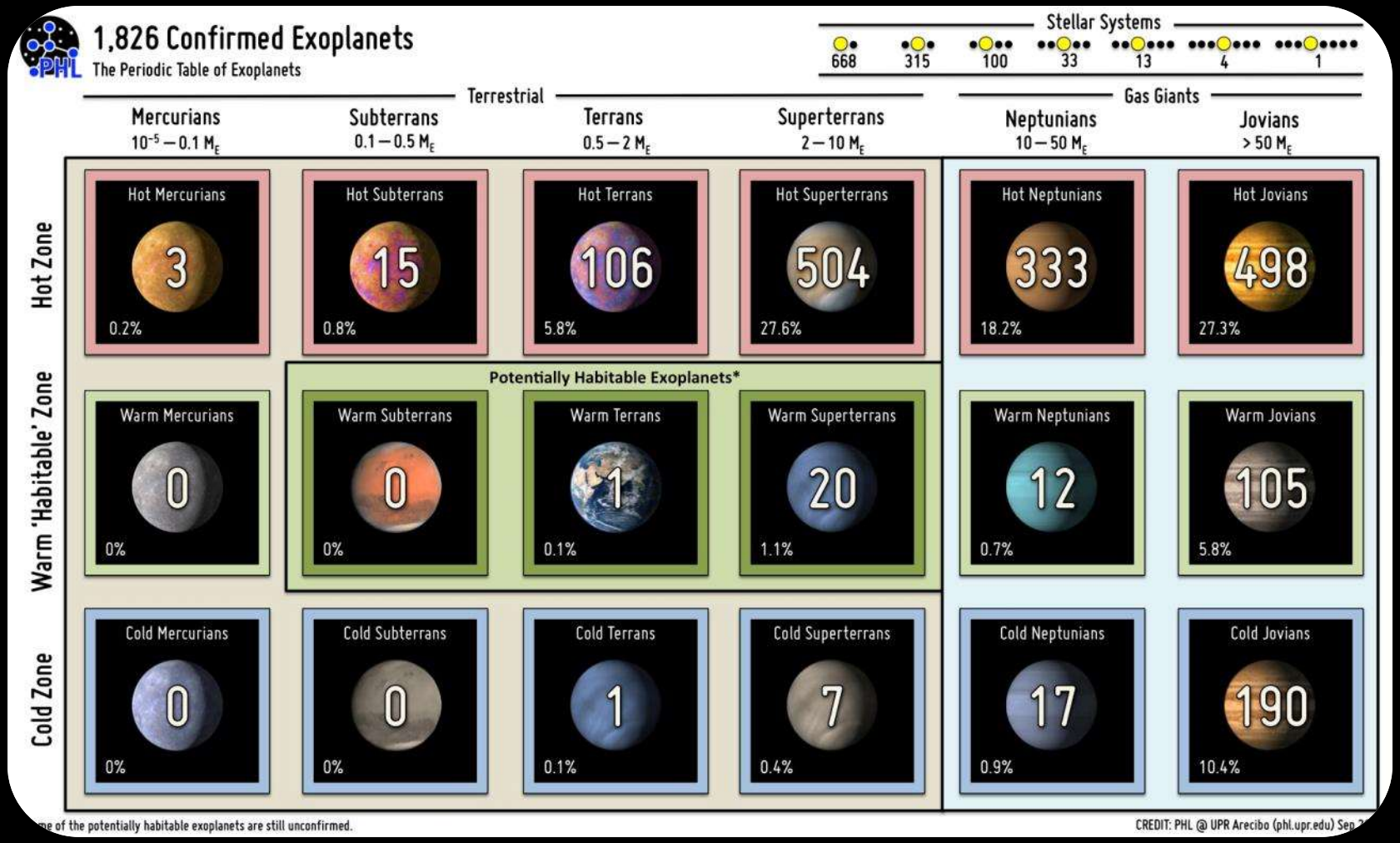
Exoplaneta habitable:

Órbita, tamaño y composición adecuados para permitir agua líquida en su superficie

Habitabilidad…el “Santo Grial”



Planetas fríos, templados y calientes



Conceptos

Exoplaneta:

Planeta que orbita una estrella diferente al Sol y que, por tanto, no pertenece a nuestro Sistema Solar

Zona habitable:

Distancia a la que orbita un exoplaneta de su estrella que permite temperatura adecuada para agua líquida en la superficie

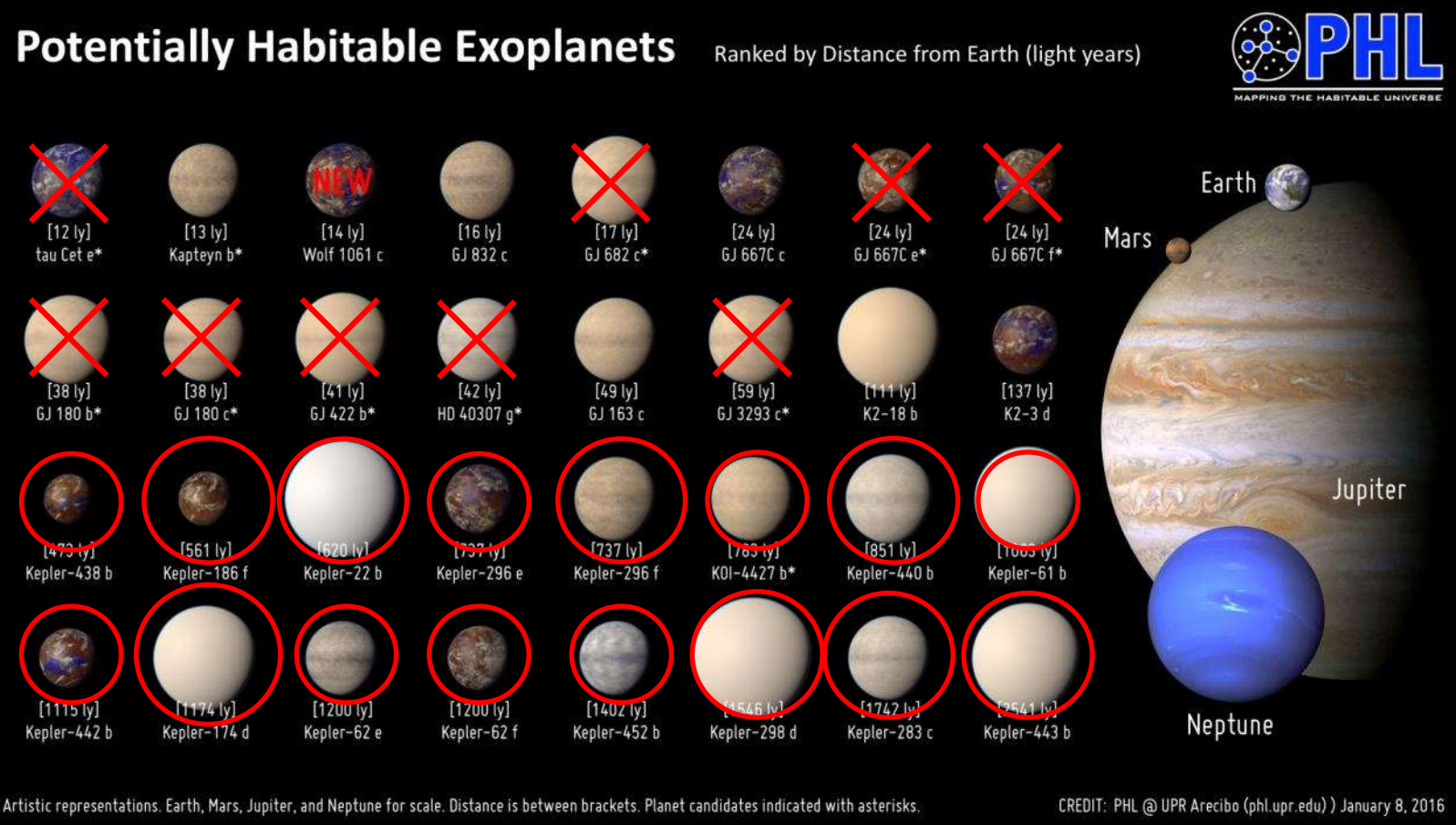
Exoplaneta habitable:

Órbita, tamaño y composición adecuados para permitir agua líquida en su superficie

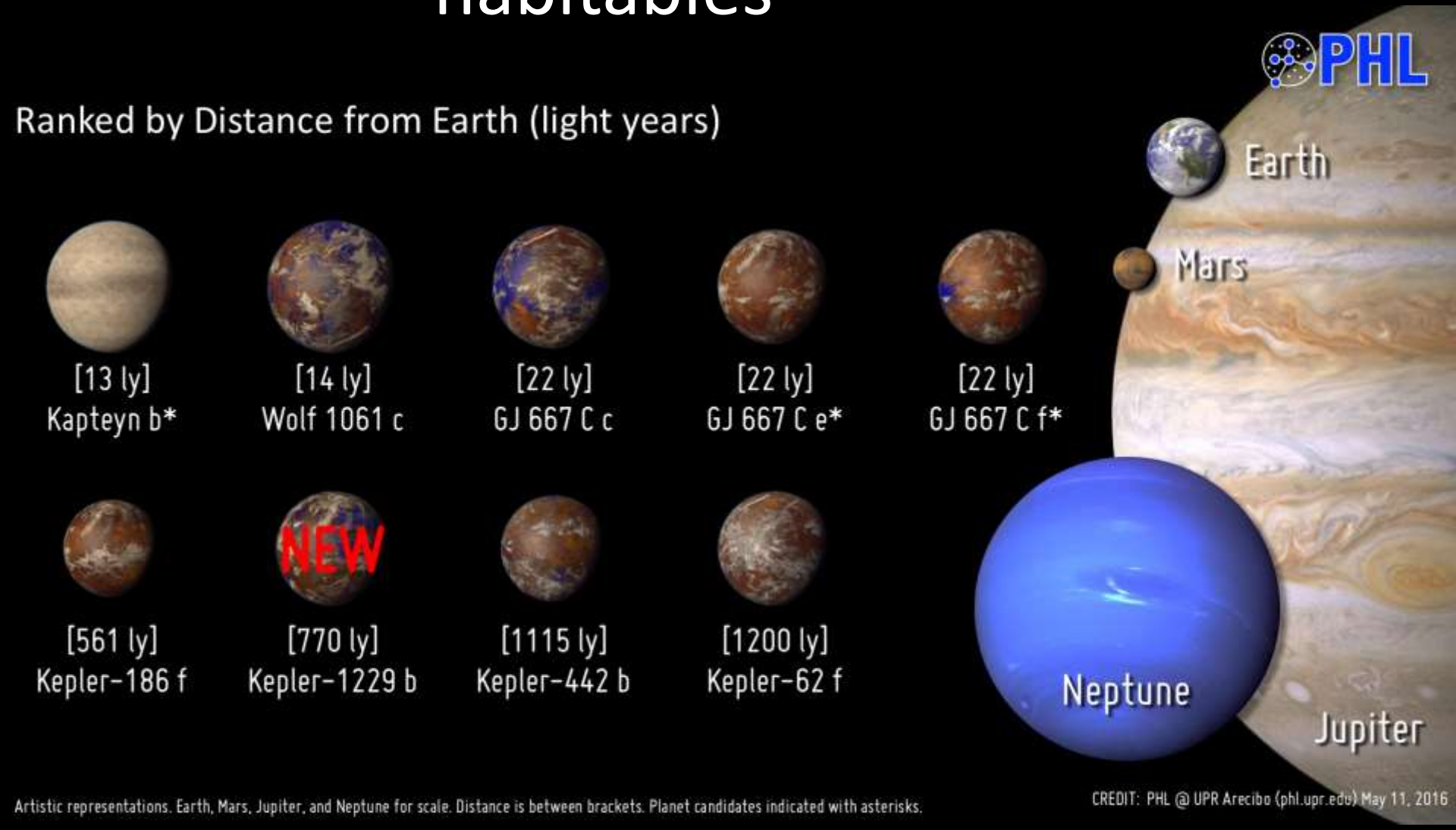
Exoplaneta habitable de tipo terrestre:

Planeta extrasolar con una masa entre 0.5 y 2 masas terrestres (o un radio entre 0.8 y 1.25 radios terrestres) orbitando en la zona habitable de su estrella

Exoplanetas potencialmente habitables

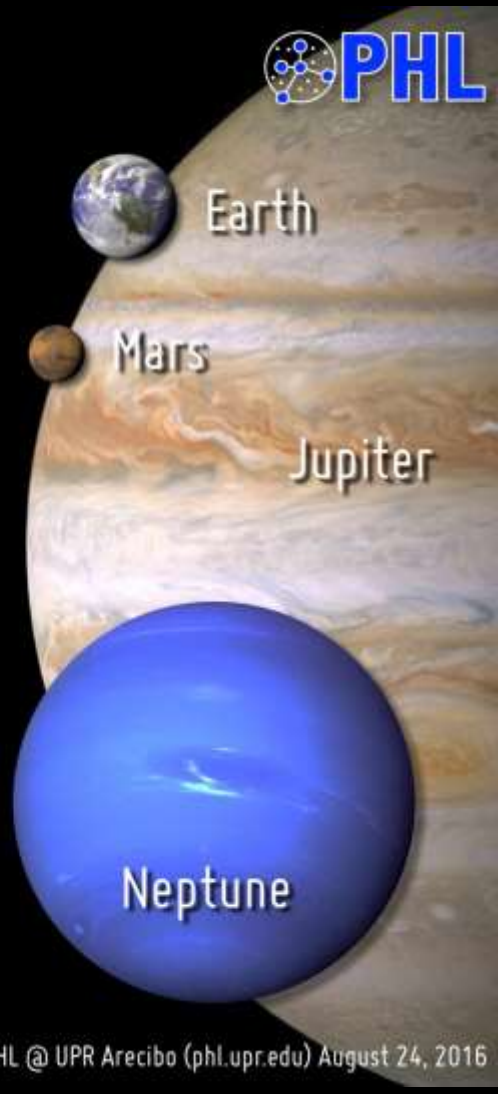


Exoplanetas potencialmente habitables



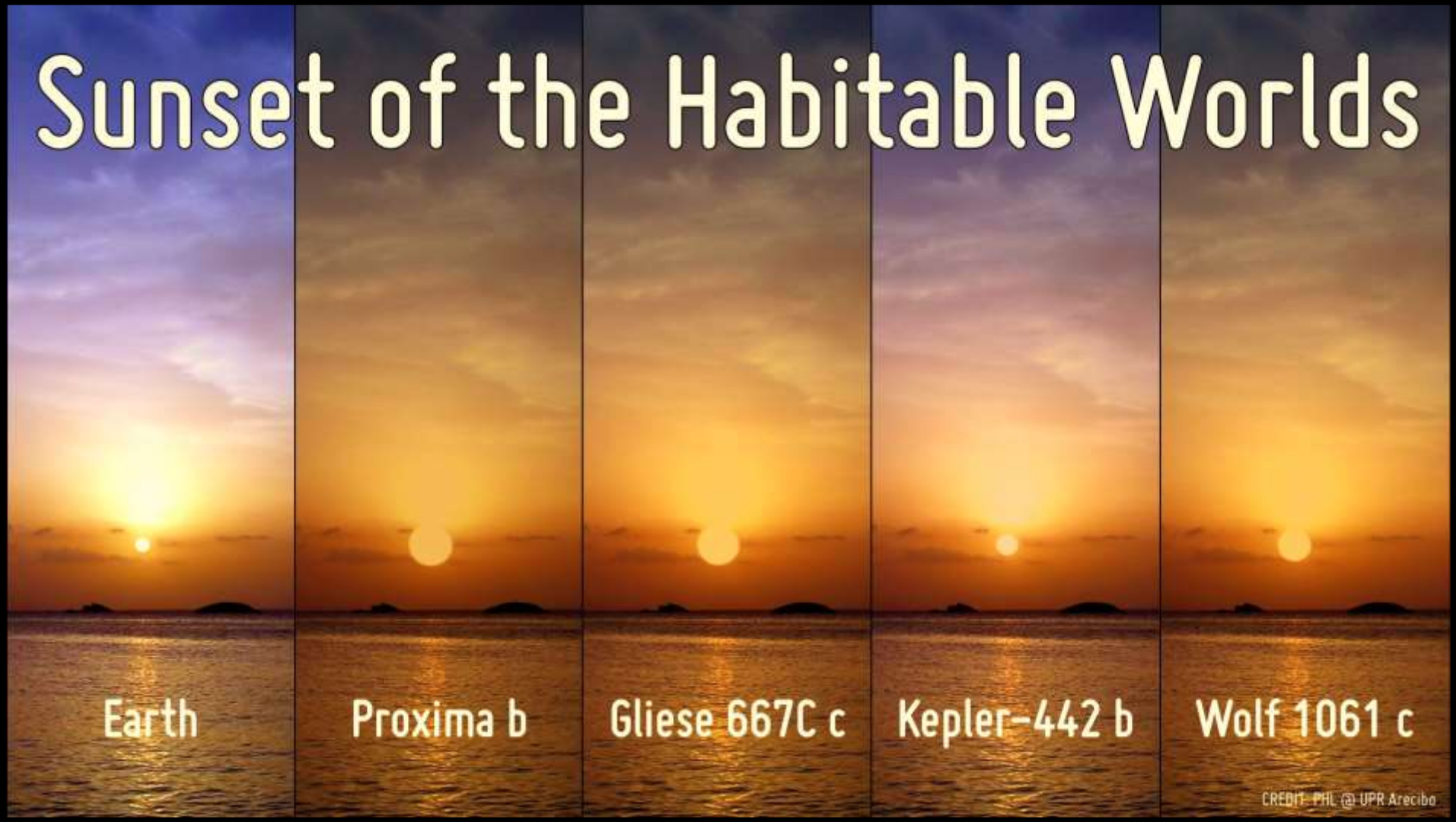
Exoplanetas potencialmente habitables

Ranked by Distance from Earth (light years)

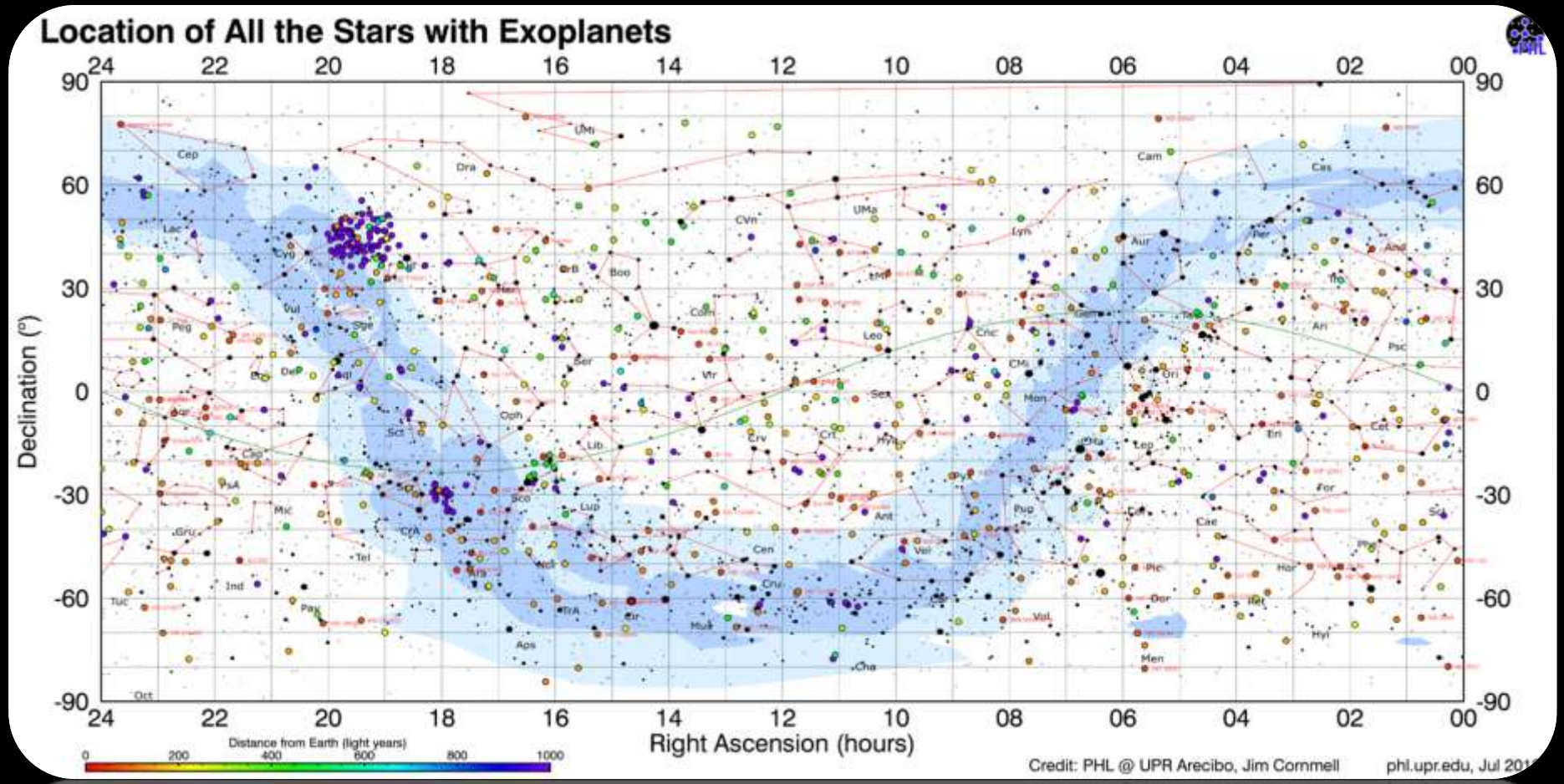


Artistic representations. Earth, Mars, Jupiter, and Neptune for scale.
Distance is between brackets. Planet candidates indicated with asterisks.

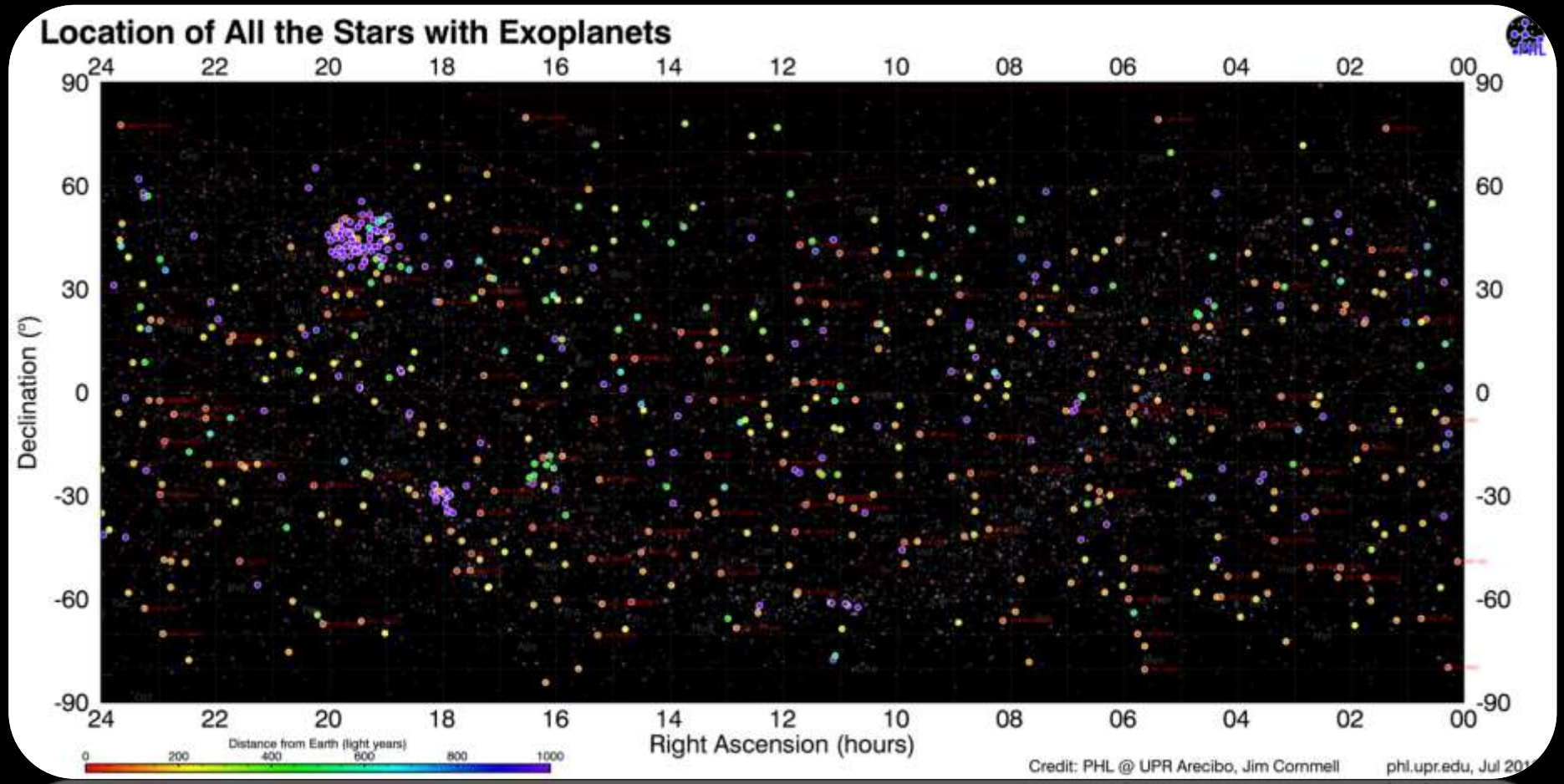
CREDIT: PHL @ UPR Arecibo (phl.upr.edu) August 24, 2016


Sunset of the Habitable Worlds
Earth
Proxima b
Gliese 667C c
Kepler-442 b
Wolf 1061 c
CREDIT: PHL @ UPR Arecibo

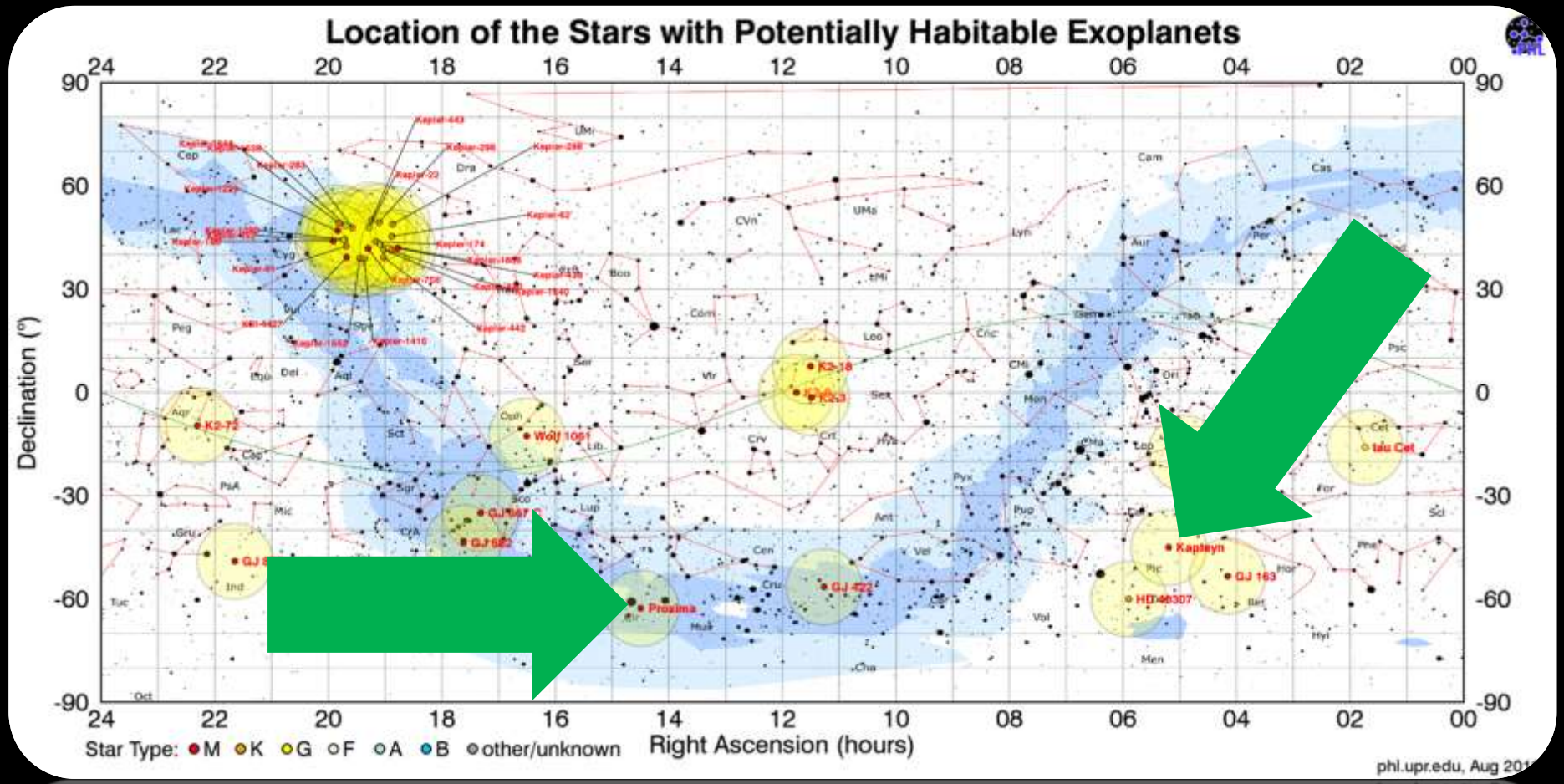
¿Dónde están estos exoplanetas?



¿Dónde están estos exoplanetas?



¿Dónde están estos exoplanetas?



¿CARMENES?

CARMENES: Planetas en la lejanía

CARMENES: Planetas en la lejanía

http://luz.iaa.es/
https://vimeo.com/113482343

CARMENES

Cálculo de high resolution search for M dwarfs with Exoplanets in the Infrared and optical

Infrarrojo cercano y óptico para el Calar Alto

RMEEEICA

carmenes

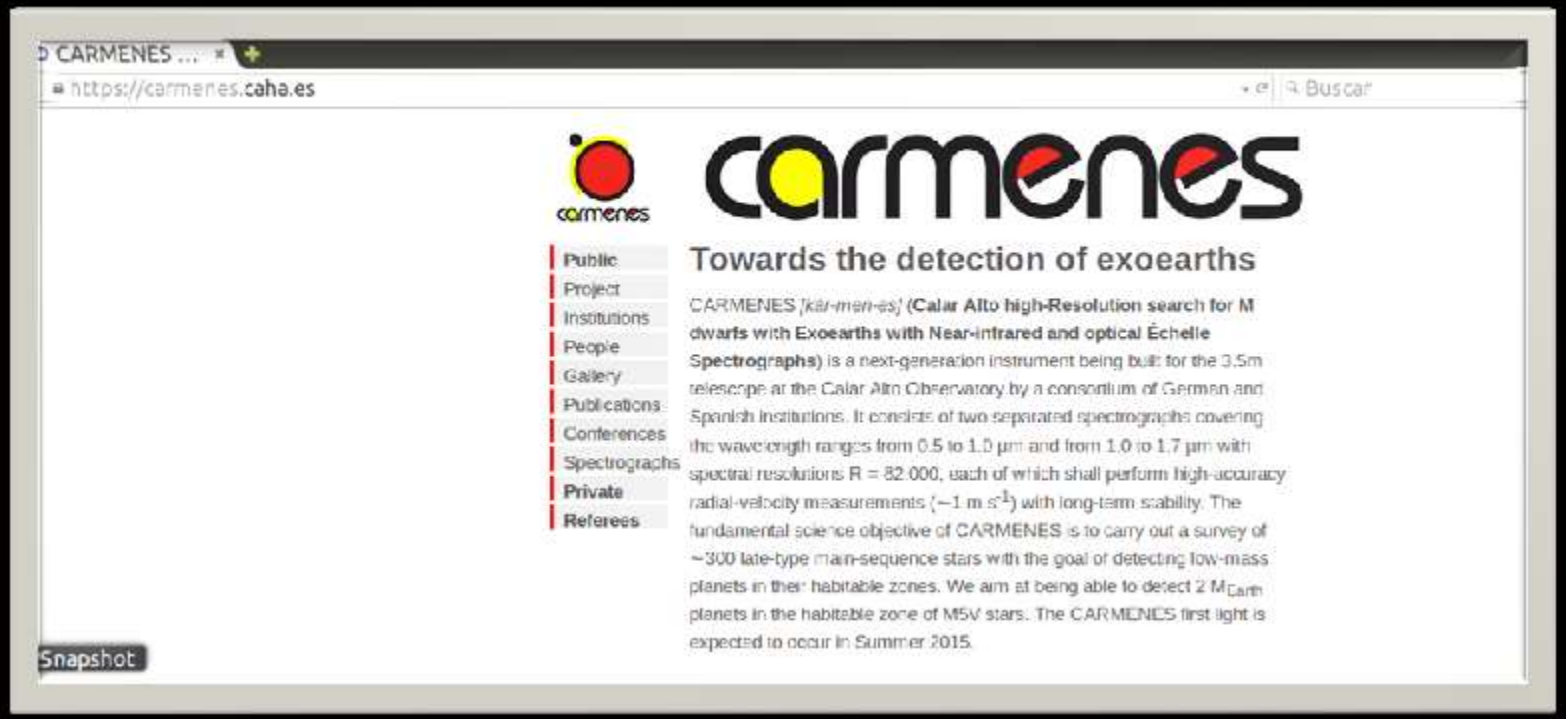
CARMENES: Consorcio

Envío a CAHA del canal NIR

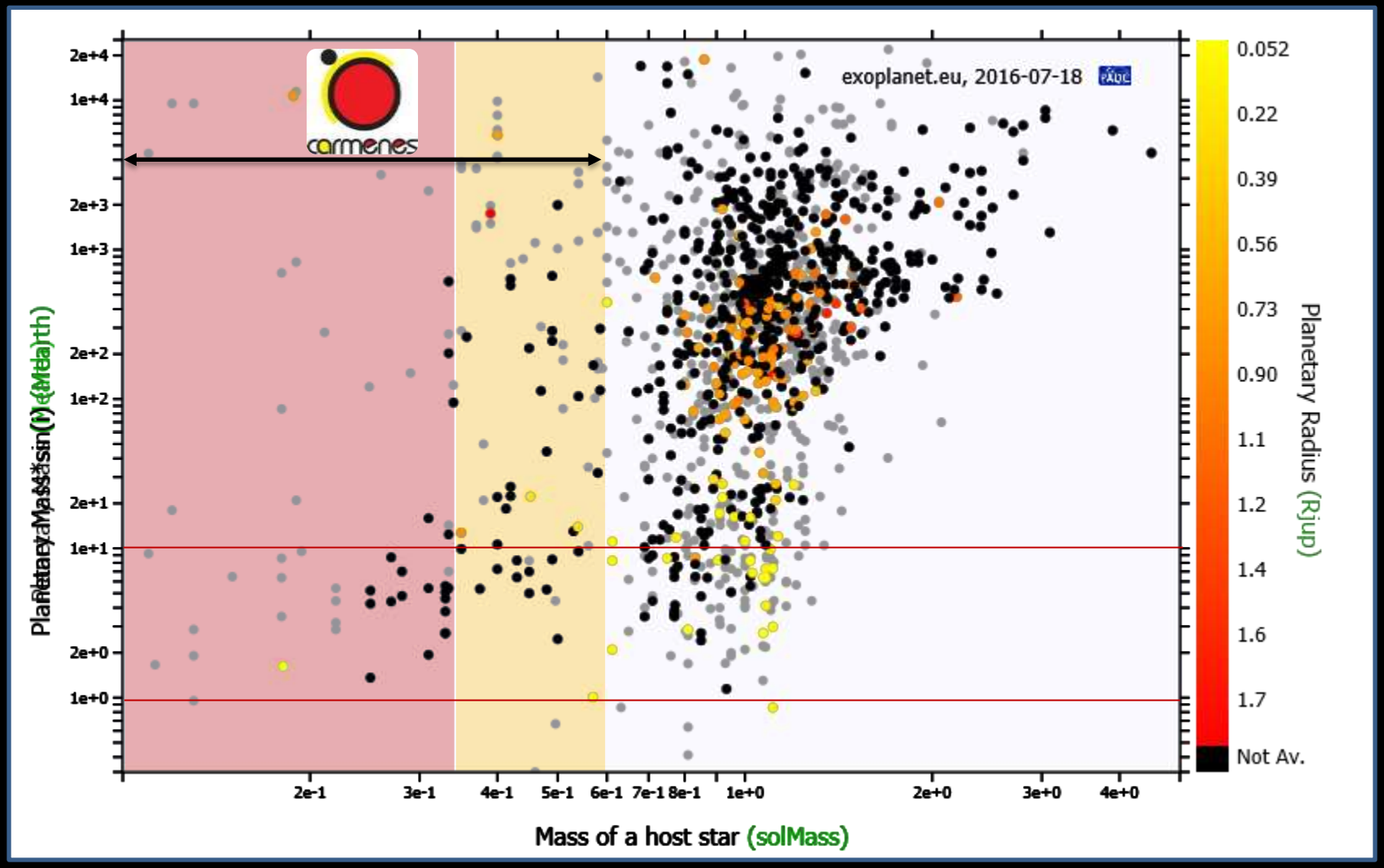
¿Por qué CARMENES?

Descubrir planetas de tipo terrestre en zona habitable alrededor de estrellas tipo M

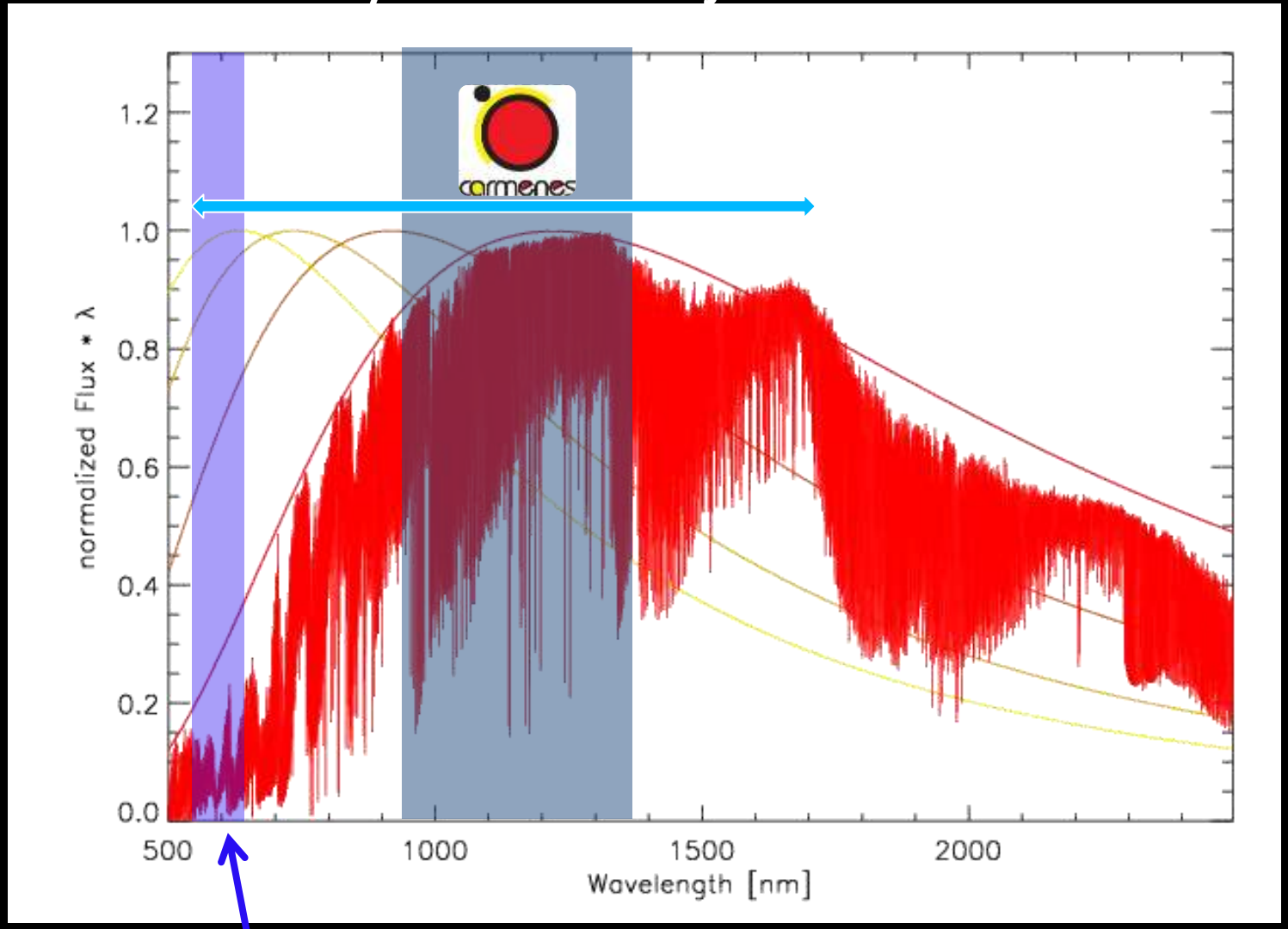
Estudiar la formación y evolución de estos exoplanetas



Un nicho científico inexplorado

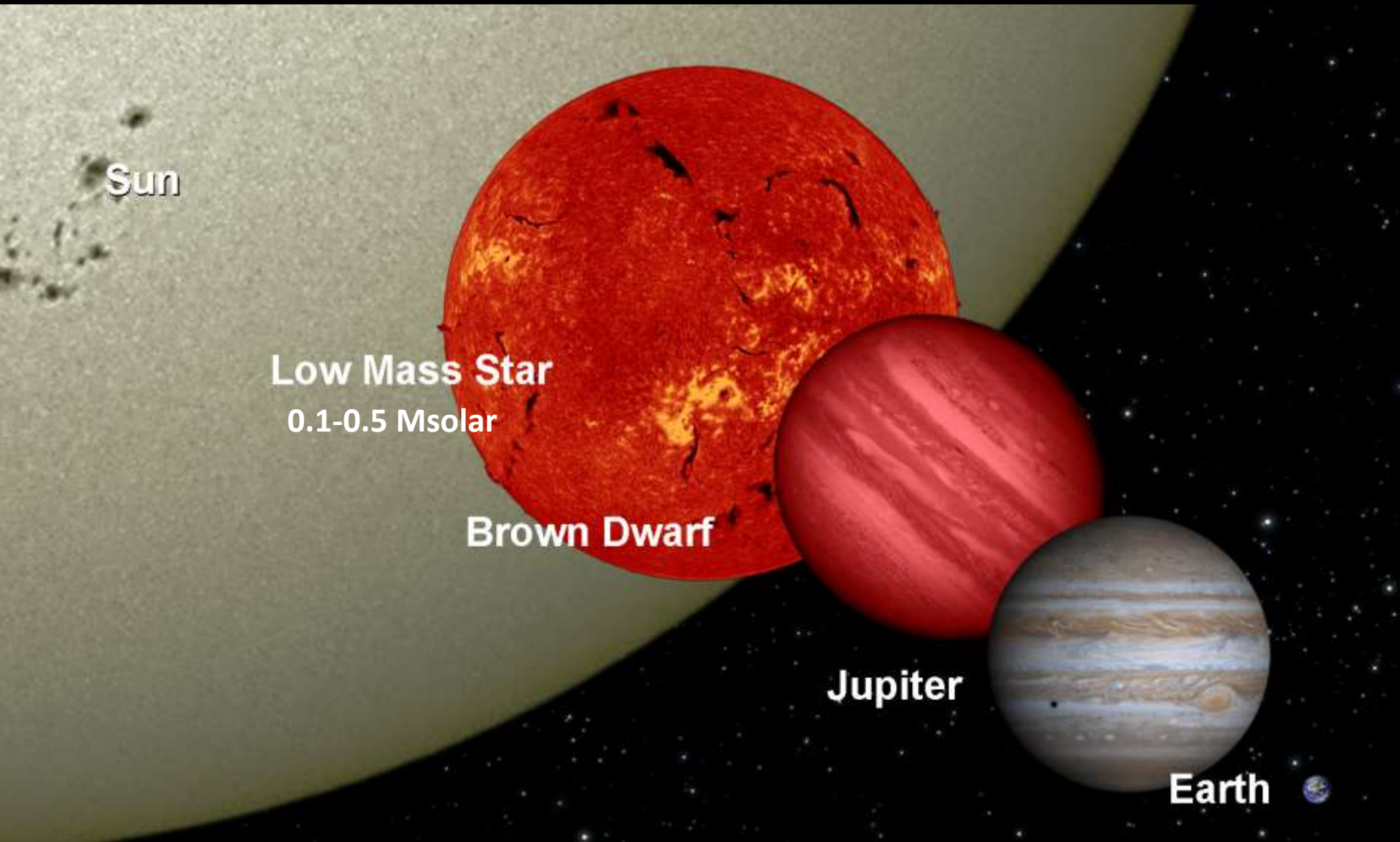


Instrumento único: gran cobertura en el visible y el infrarrojo cercano



"classical" *visible light* RV instruments

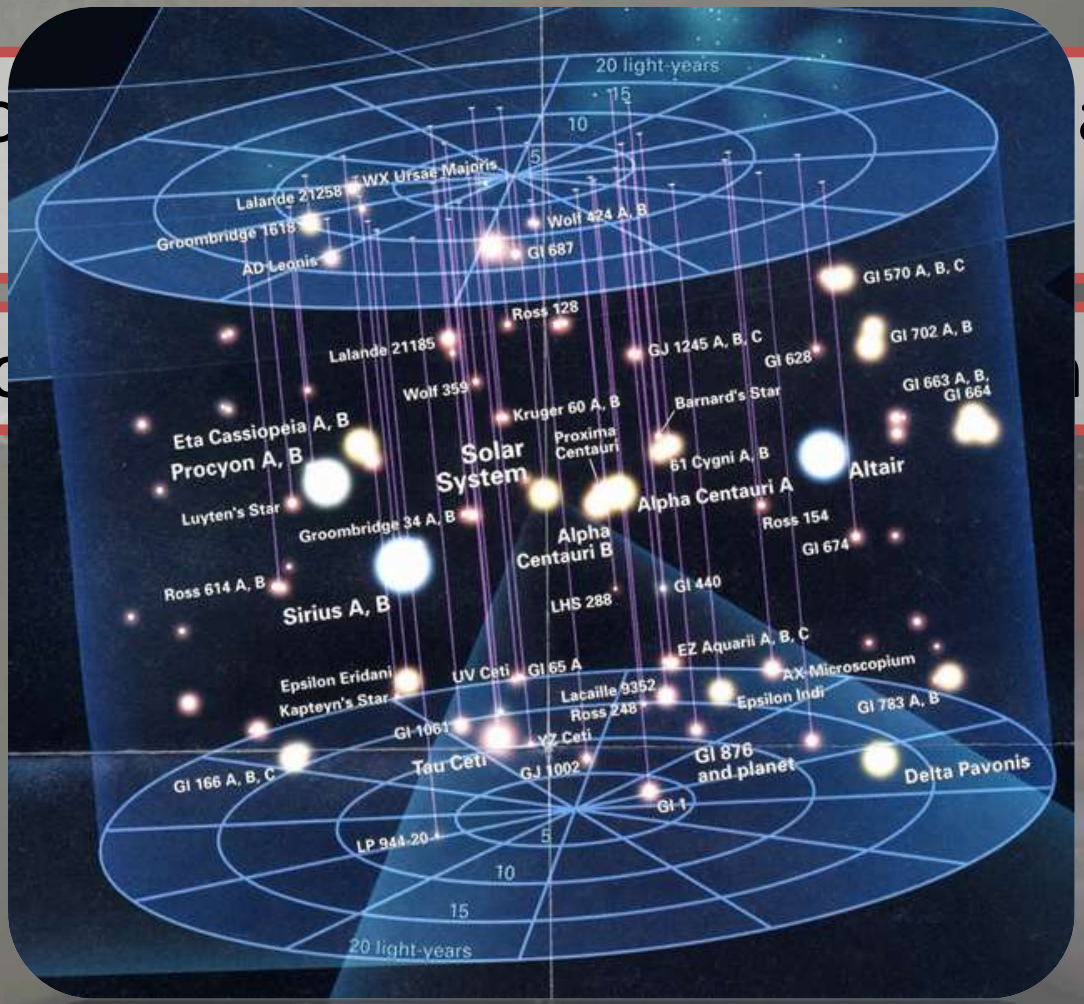
Enanas rojas tipo M



¿Por qué buscar en estrellas M?

¡¡7 de c axia son

Sc nos



Earth

¿Por qué buscar en estrellas M?

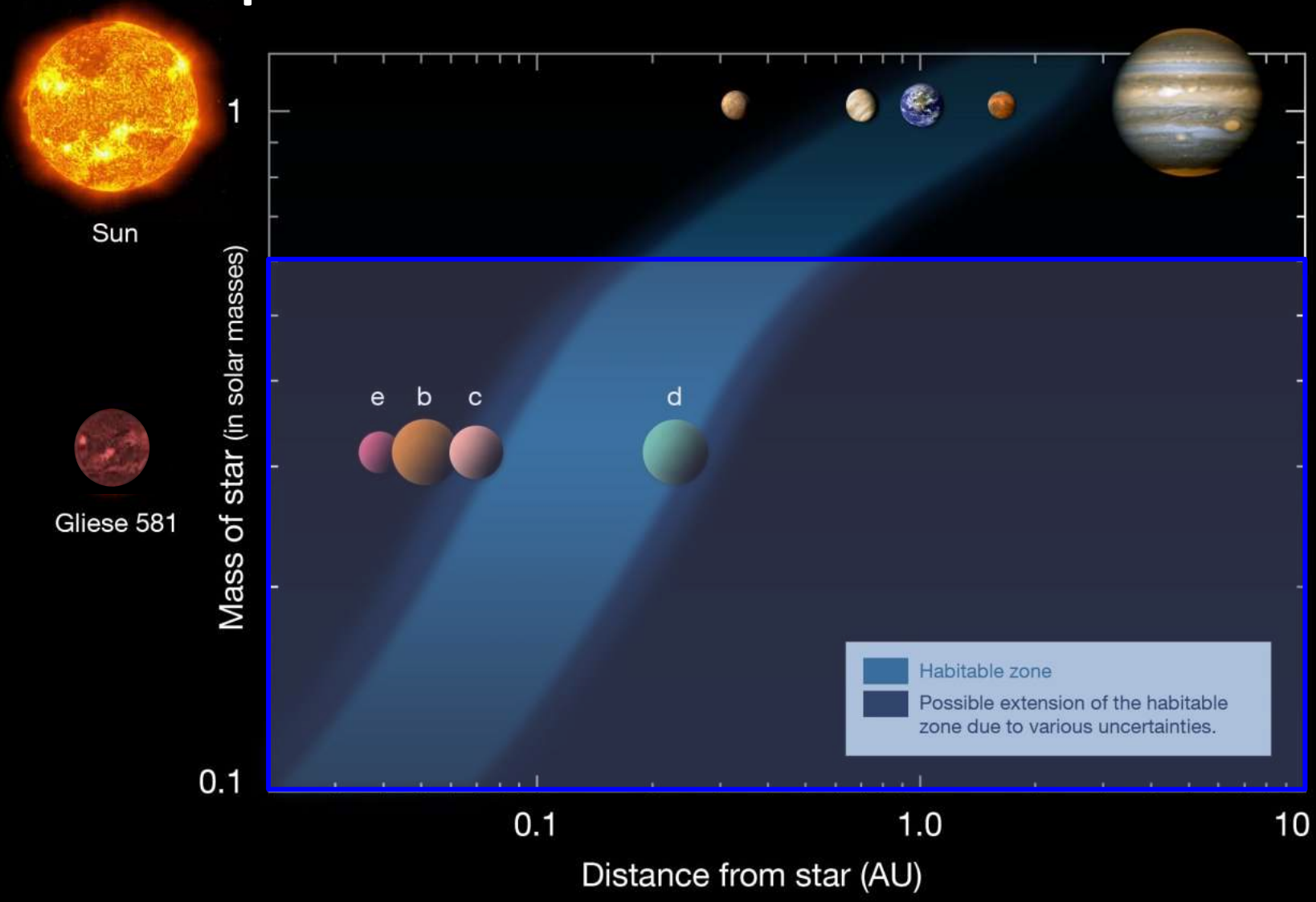
¡¡7 de cada 10 estrellas en nuestra Galaxia son enanas M!!

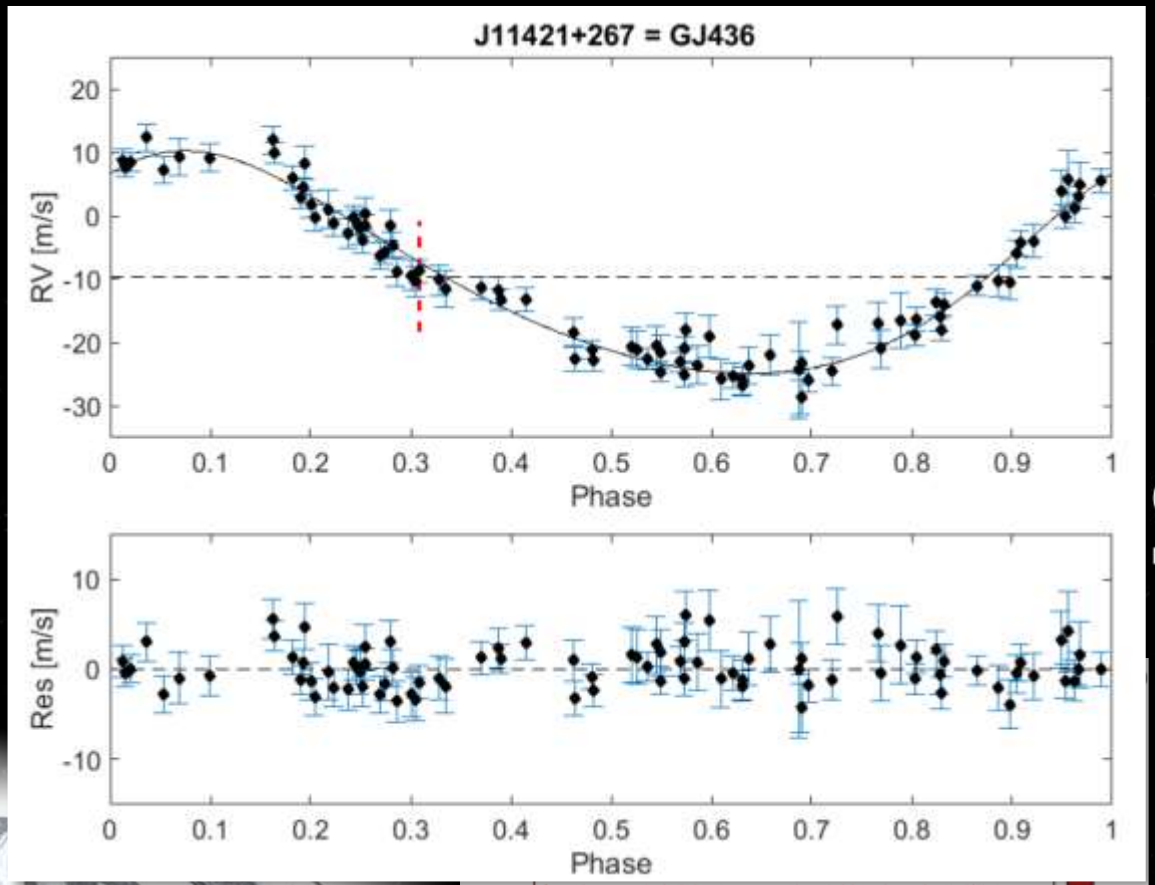
Son nuestros vecinos más cercanos

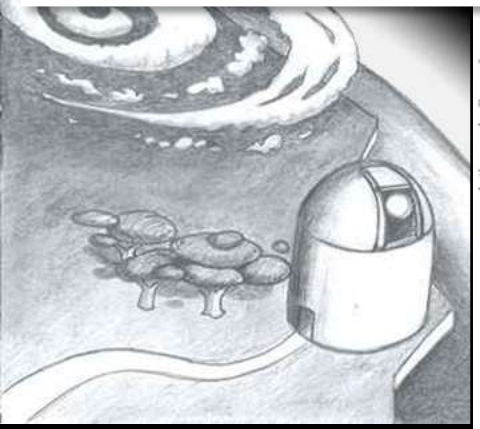
Mayor tiempo de vida estable: más tiempo para que se desarrolle la vida

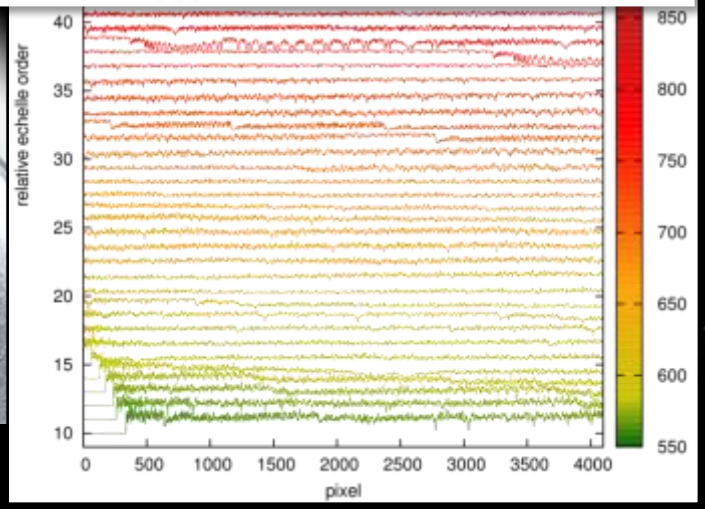
Más frías: ZH más cerca

¿Por qué buscar en estrellas M?



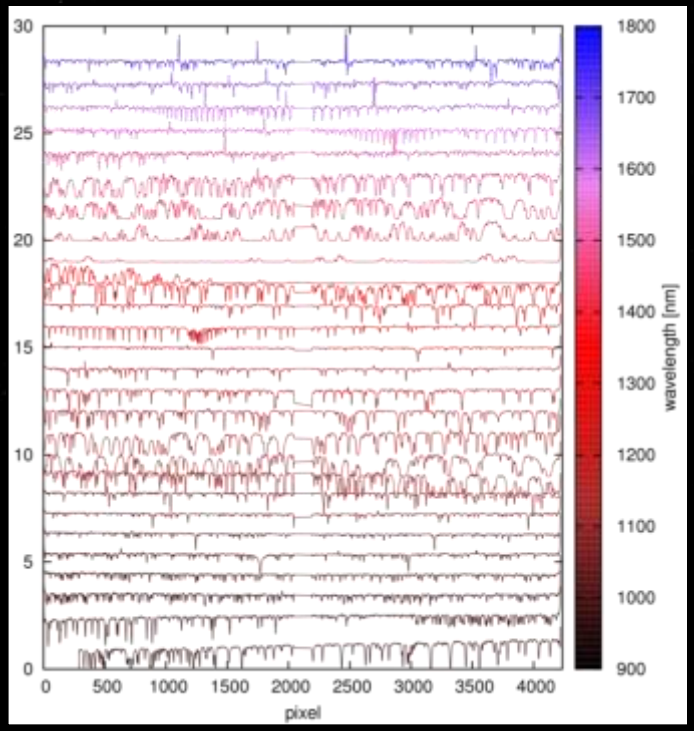




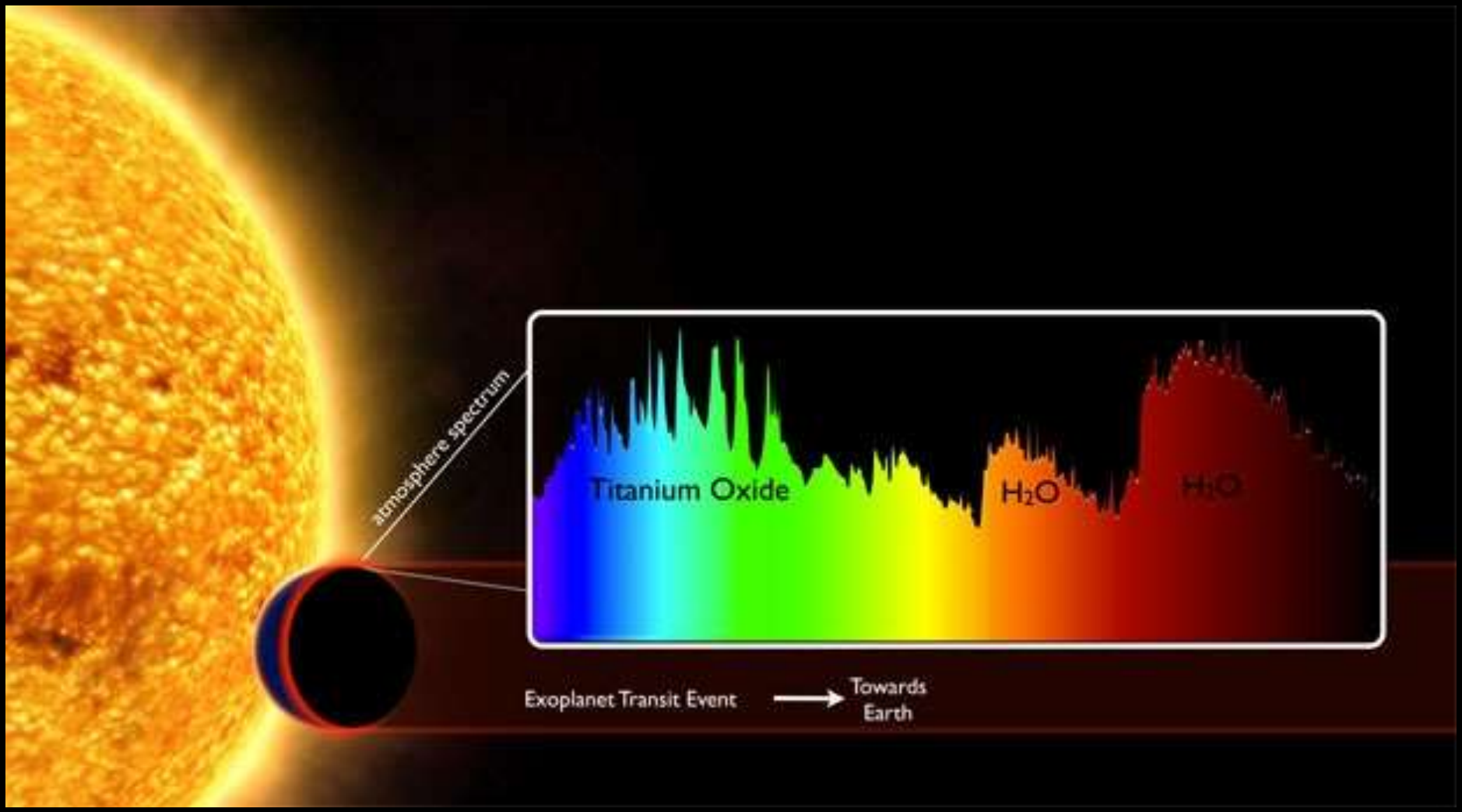


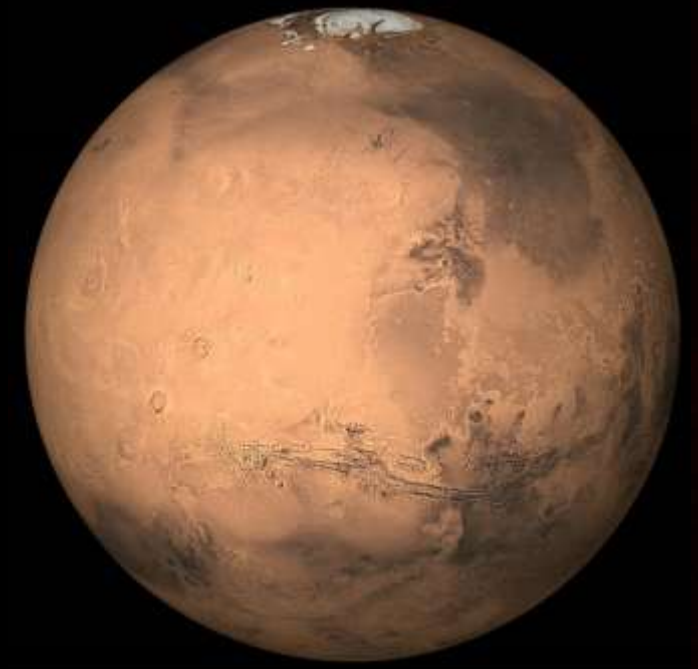
the science

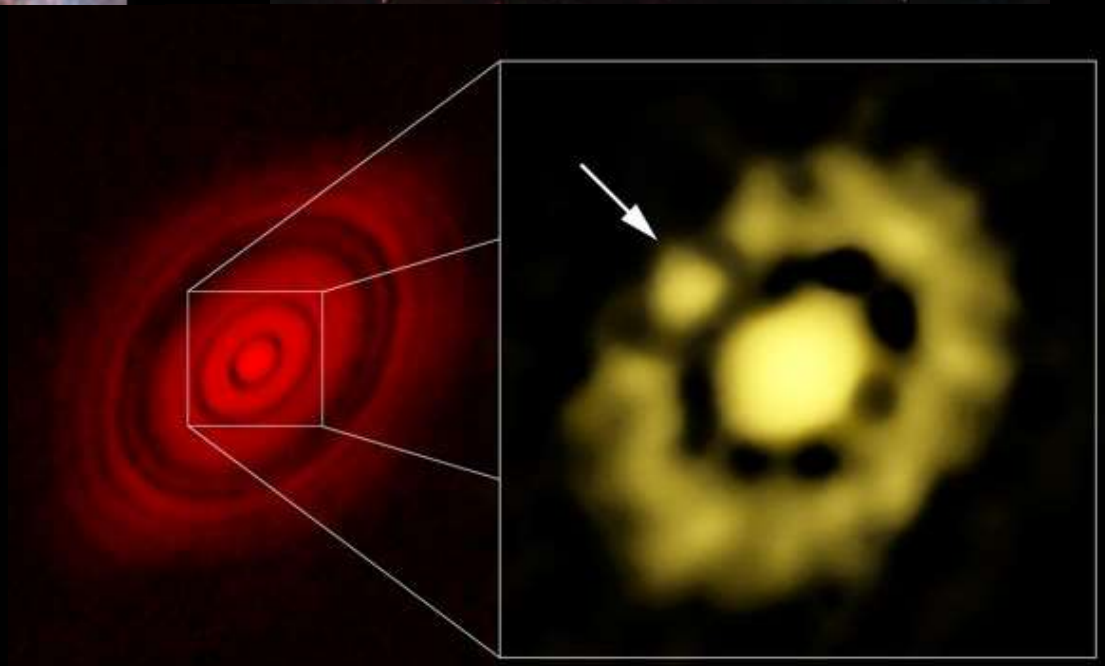
CARMENES NIR spectrum



Caracterización de atmosferas exoplanetarias

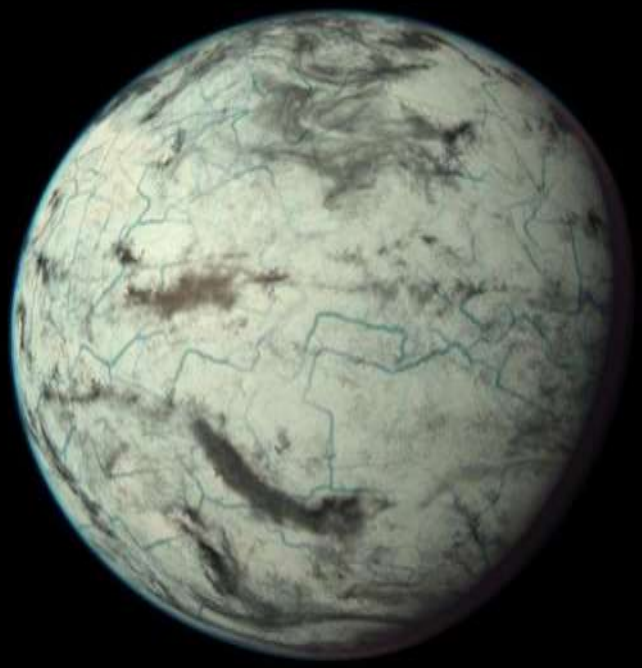






HL Tau

Fuente: Carrasco-Gonzalez, et al.; Bill Saxton, NRAO/AUI/NSF

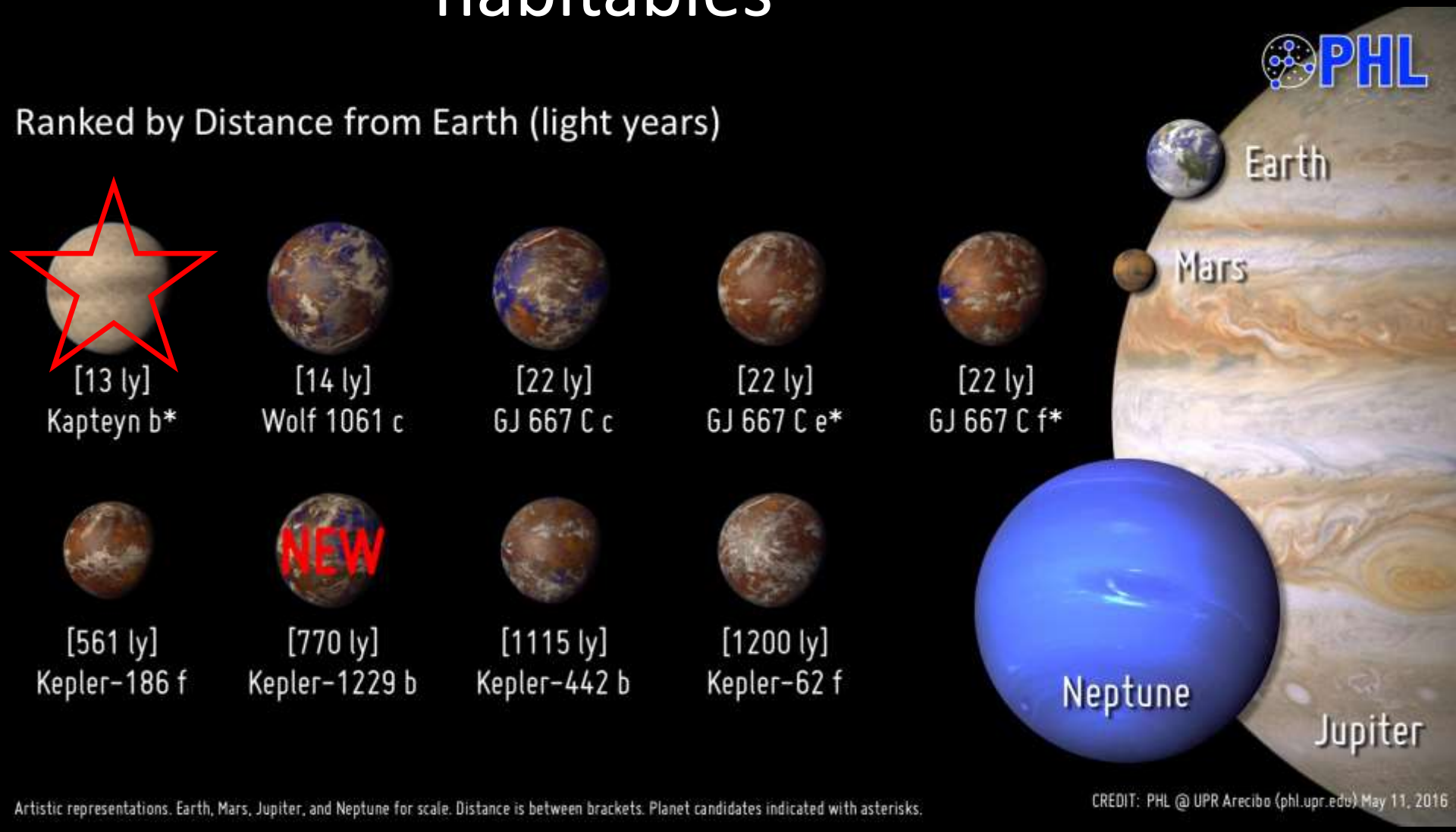


Kapteyn b

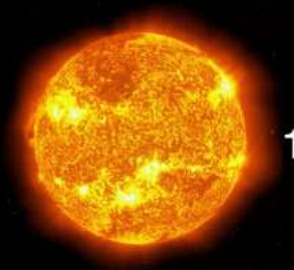
Earth

CREDIT: PHL @ UPR Arecibo

Exoplanetas potencialmente habitables



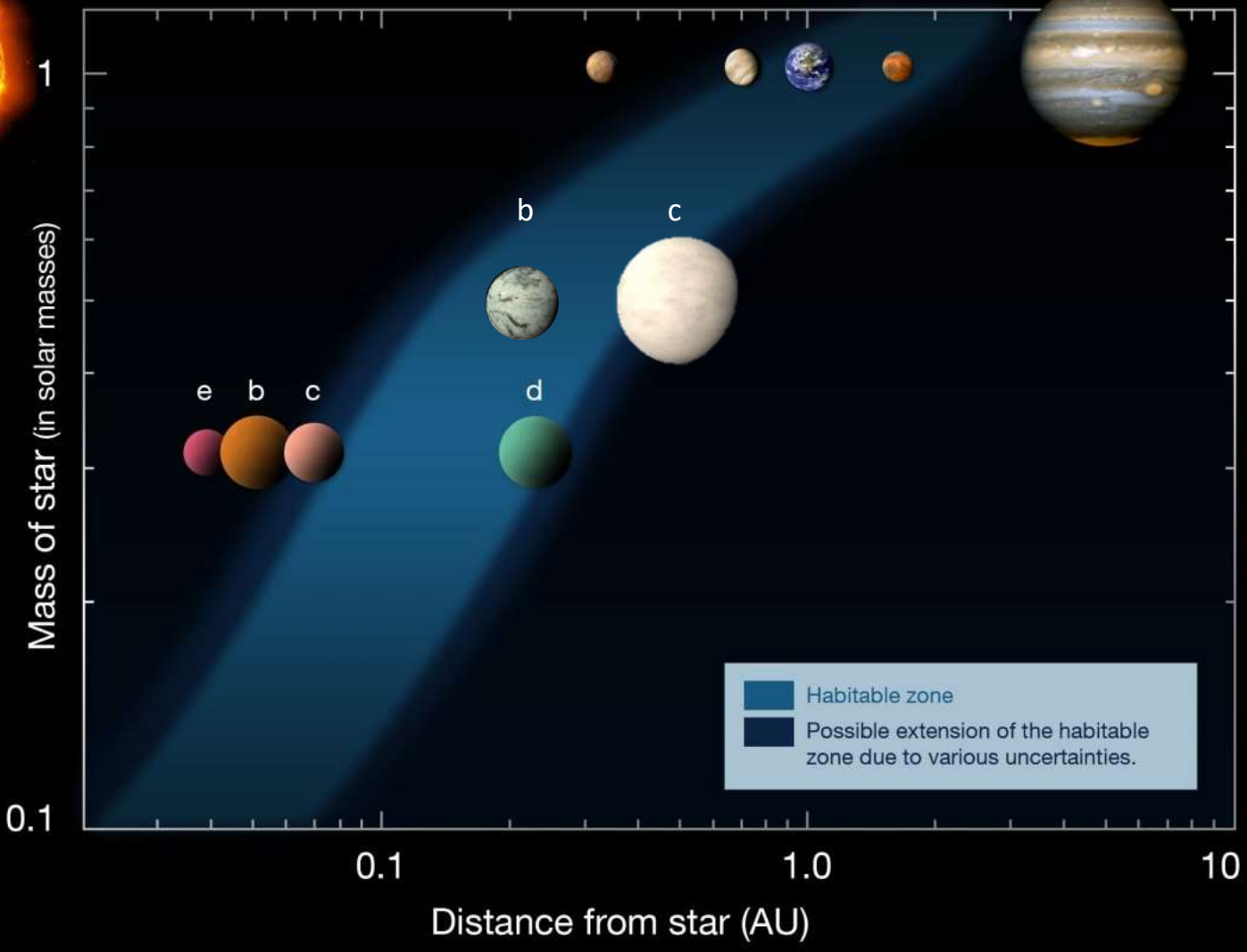
Kapteyn b en la zona de habitabilidad



Sun

Kapteyn

Gliese 581



Mail Online

Have scientists discovered Earth 2.0? Planet just 13 light years away could harbour life that originated OUTSIDE the Milky Way

A planet that may harbour life has b
Kapteyn b is one of two planets aro
It is the first potentially habitable pl
Its star originally came from a dwar
And the planets might be just 2 billi
US co-author Dr Arriagada says the

EL HUFFINGTON POST

Scientists Say This Nearby Planet May Be The Oldest Capable Of Supporting Alien Life

Los Angeles Times

Science Now

Discoveries from the world of science and medicine

Two ancient worlds found just 13 light-years from Earth

Alastair Reynolds: Sad Kapteyn – Desolada Kapteyn

4 News

How close are we to discovering alien life?

An alien world covered in cities and giant structures that reach into the heavens - science fiction, or is science on the verge of discovering extra-terrestrial life?

NATIONAL GEOGRAPHIC

Super Earths Found Circling Ancient Star

Posted by **Andrew Fazekas** in StarStruck on June 3, 2014

Newsweek

Newly Found Planet May Have Flowing Water, Astronomers Report

By *Zoë Schlanger*

Filed: 6/3/14 at 7:00 PM

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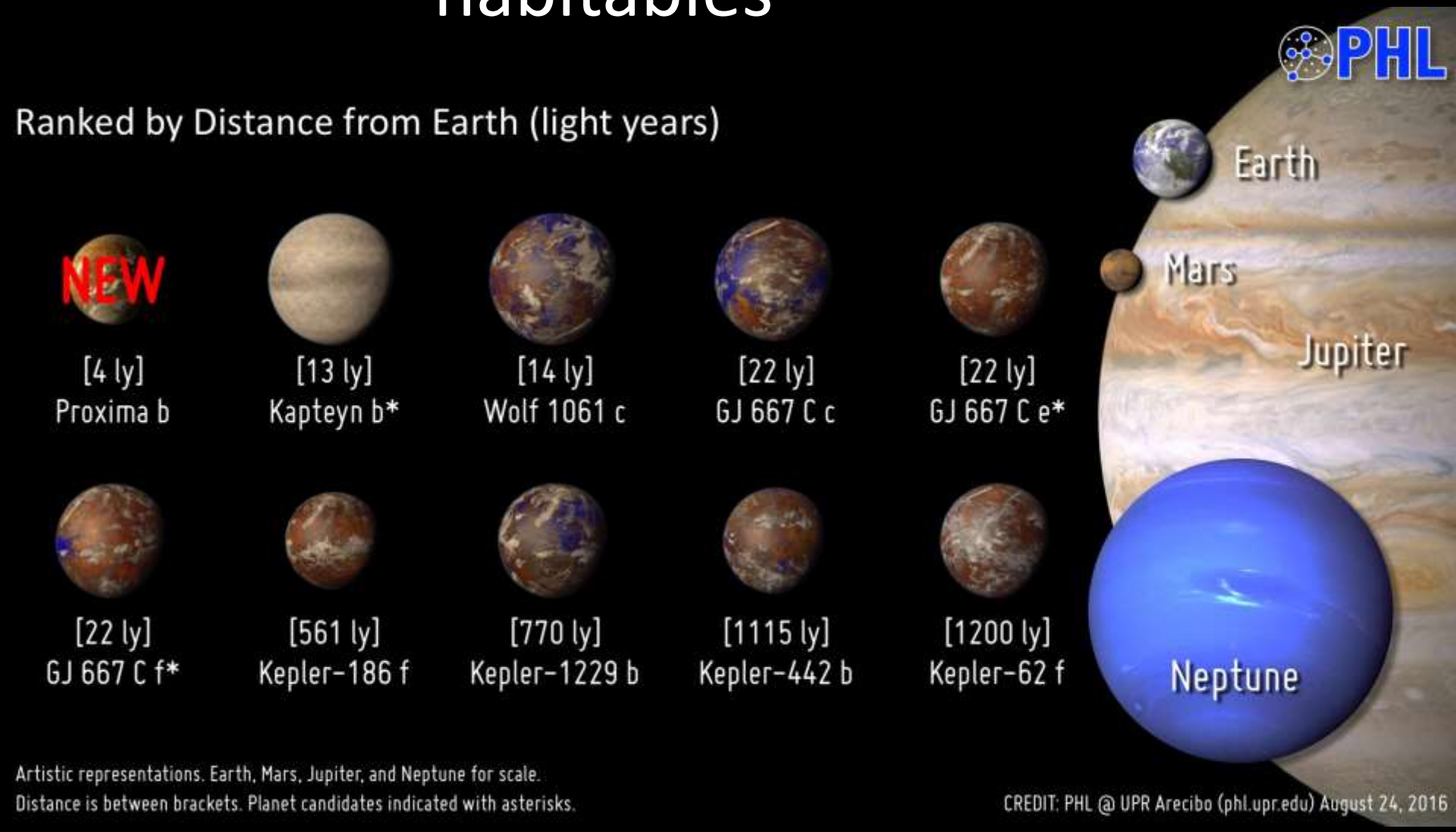
Proxima b: el planeta de tipo terrestre y templado mas cercano

Earth

Proxima b
(artistic representation)

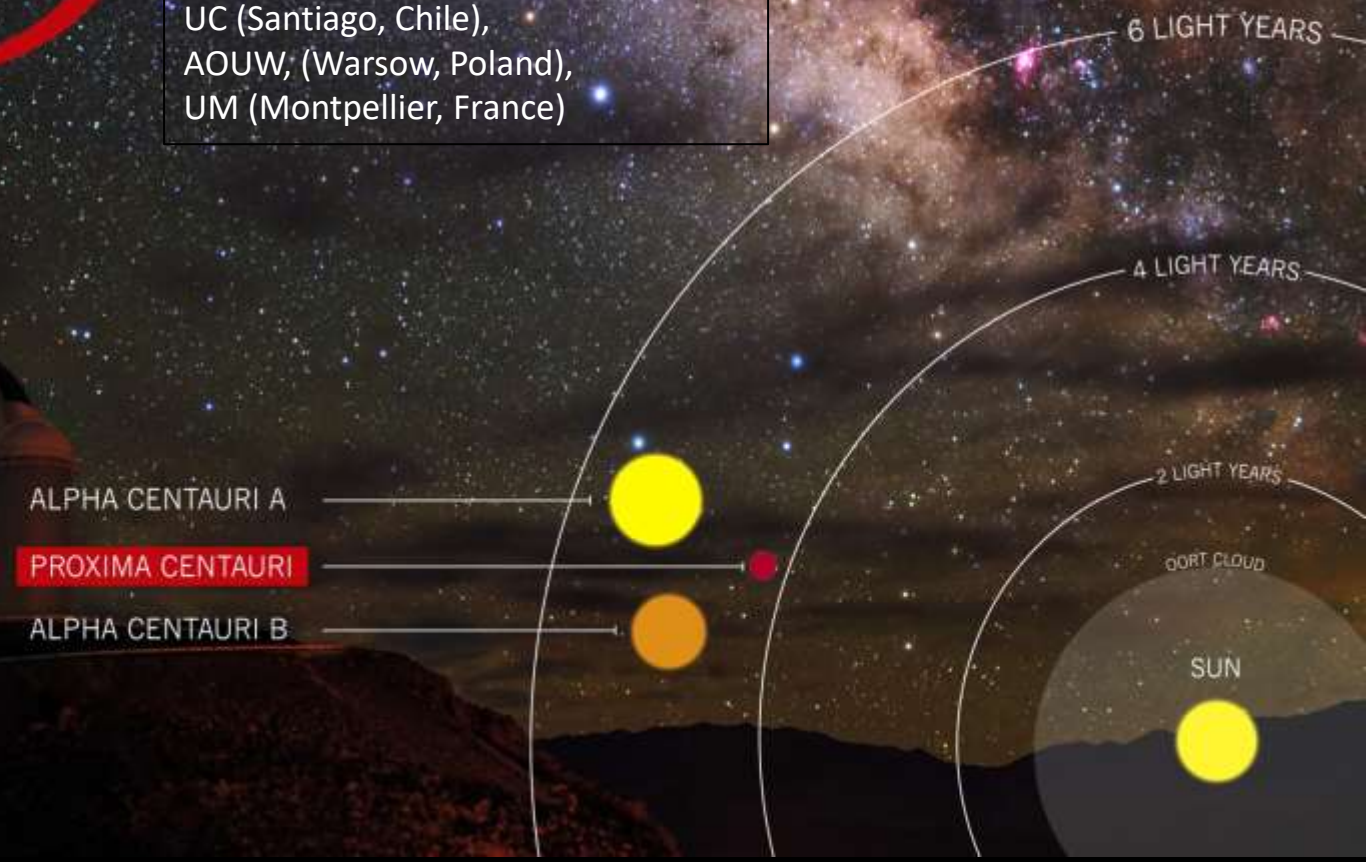
Credit: PHL @ UPR Arecibo, NASA EPIC Team

Exoplanetas potencialmente habitables



PALE RED DOT

QMUL (London, United Kingdom)
UH (Hertsfordshire, United Kingdom)
OU (Milton Keynes, United Kingdom)
IAA-CSIC (Granada, Spain)
UG (Göttingen, Germany)
MPIA (Heidelberg, Germany)
CIS (Washington, USA)
UT (Texas, USA),
WIS (Rehovot,Israel),
UC (Santiago, Chile),
AOUW, (Warsow, Poland),
UM (Montpellier, France)



https://palereddot.org/

PRD@IAA

Eloy Rodriguez

José Luis Ortiz

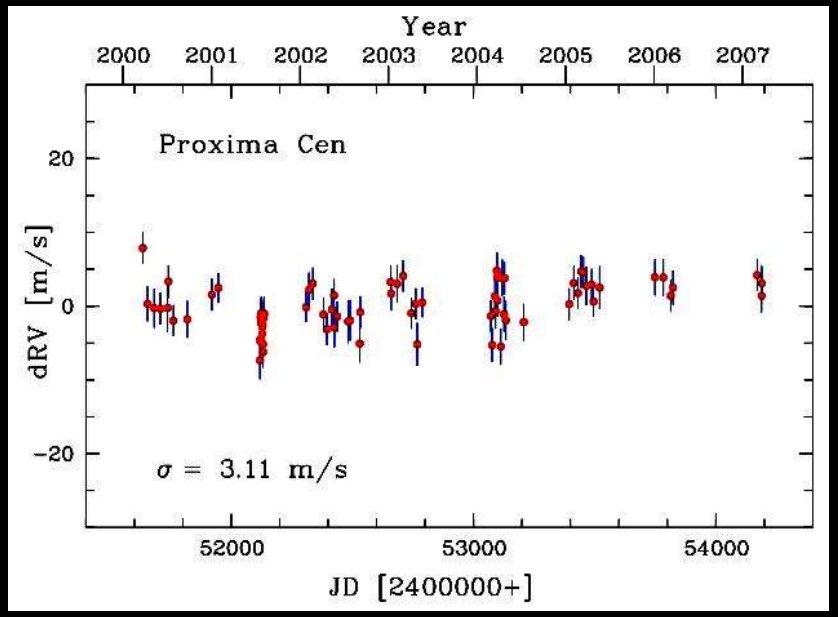
Nicolás Morales

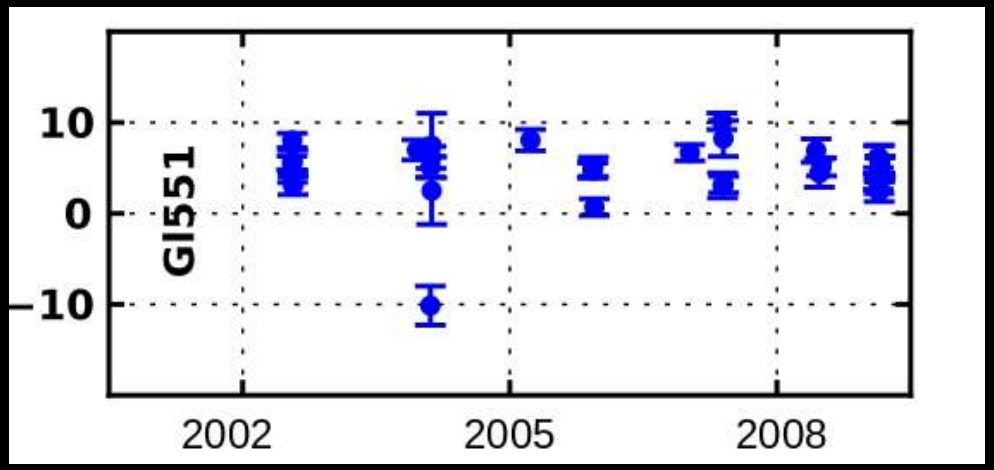
Crux
Musca
Proxima
Centaurus
α
Circinus

Alpha Centauri A & B
17'

Proxima Centauri

Campañas pre-Pale red dot





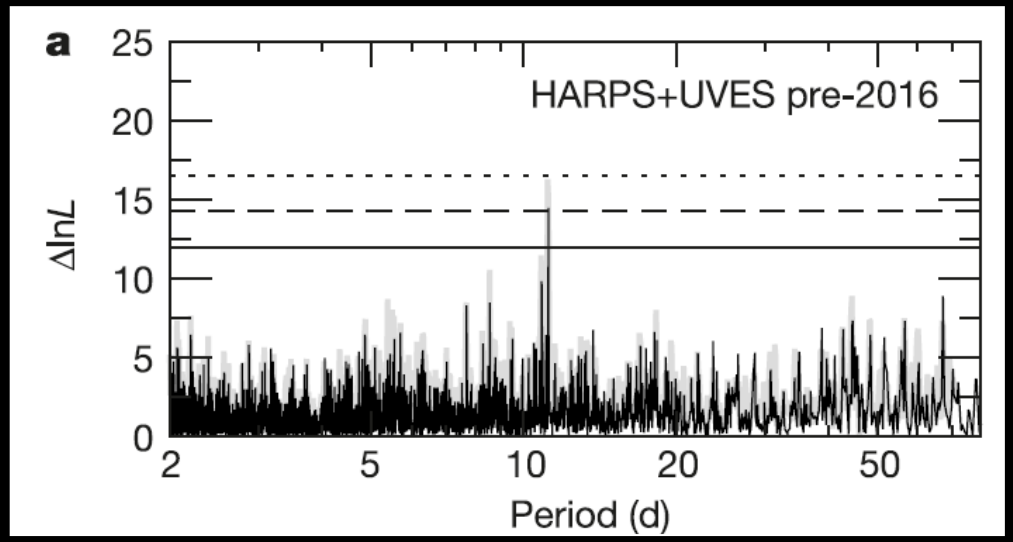
UVES/ESO survey
(Endl &Kürster 2008)

Geneva team HARPS survey
(Bonfils et al. 2013)

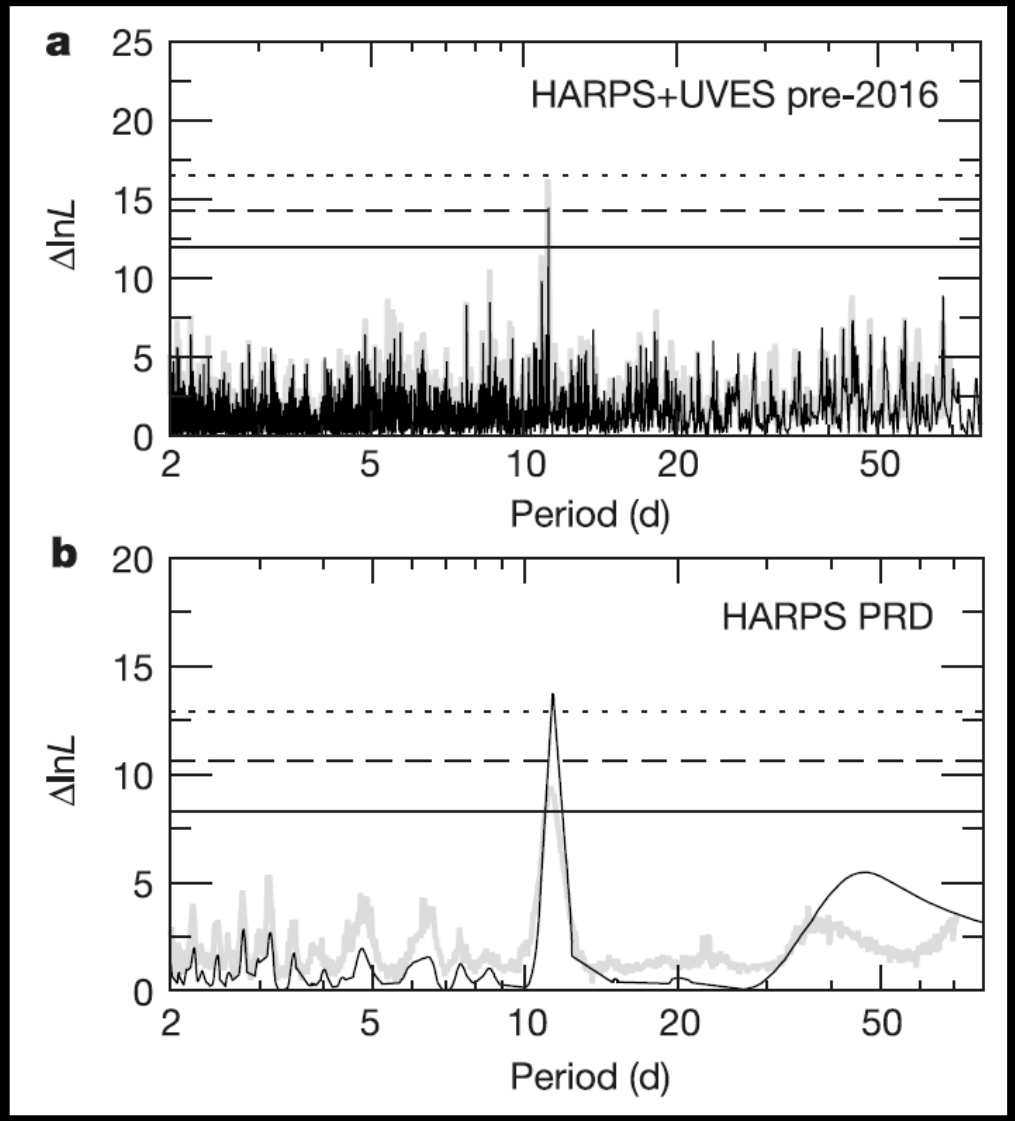
Cool Tiny Beats HARPS survey
(2013-2015)

	# obs
2000-2008 : UVES search	232
2002-2015 : HARPS pre-2016	264
2016-now : HARPS Pale Red Dot	**54**

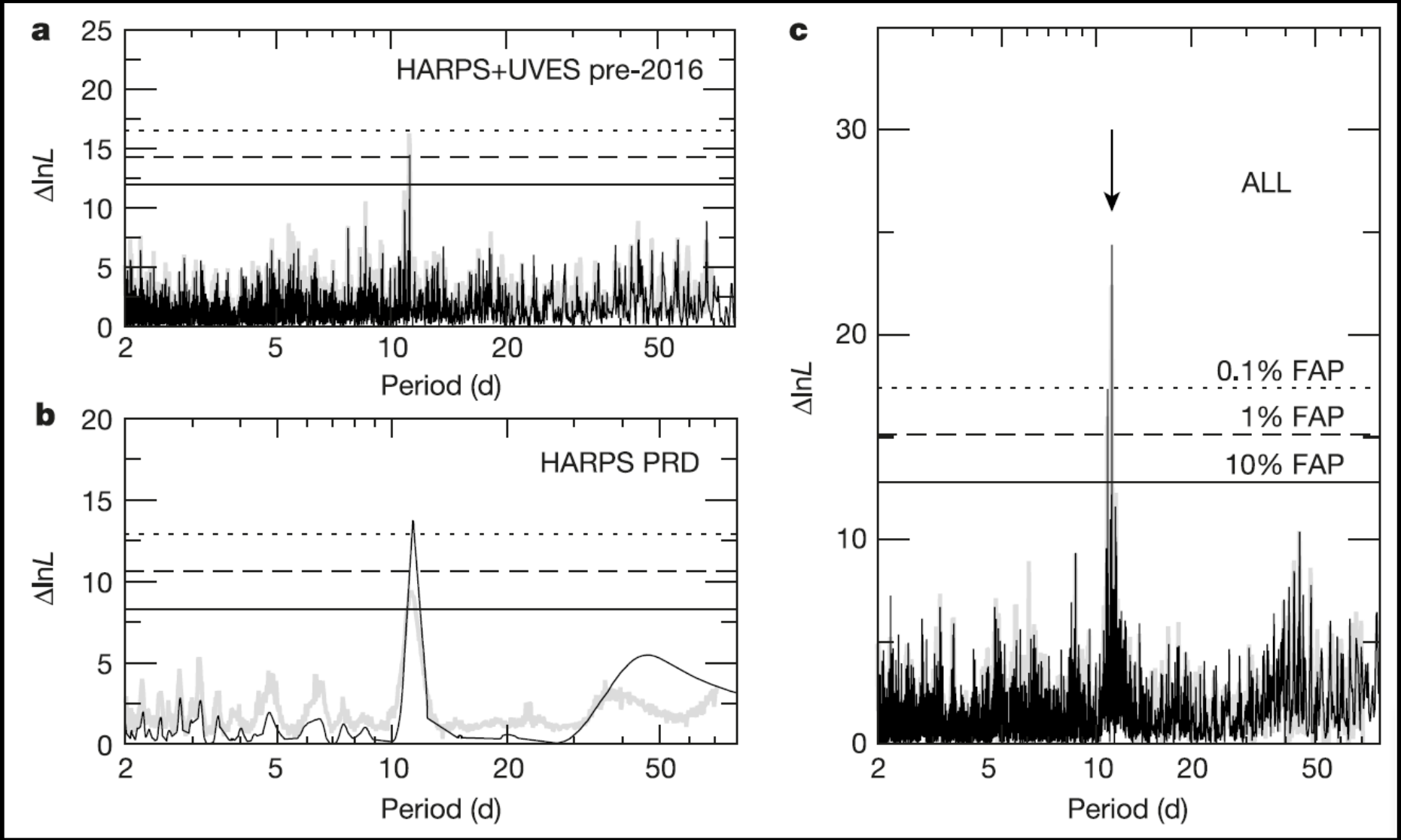
La señal



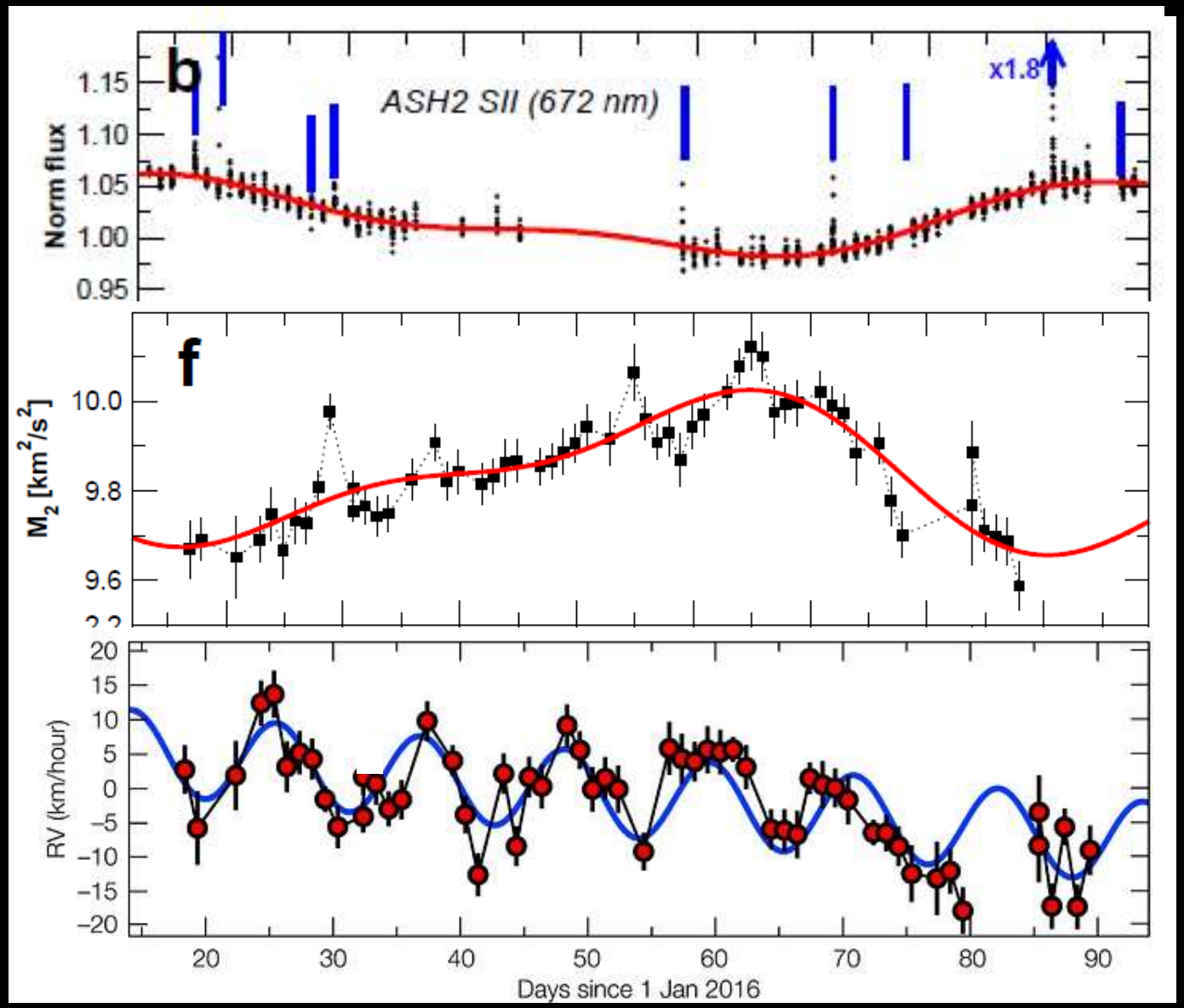
La señal


a
HARPS+UVES pre-2016
ΔlnL
25
20
15
10
5
0
2
5
10
20
50
Period (d)
b
HARPS PRD
ΔlnL
20
15
10
5
0
2
5
10
20
50
Period (d)

La señal


a
HARPS+UVES pre-2016
ΔlnL
Period (d)
b
HARPS PRD
ΔlnL
Period (d)
c
ALL
0.1% FAP
1% FAP
10% FAP
ΔlnL
Period (d)

Pale red dot: activity?



Photometry

Line width

Doppler

Proxima b esta en la Zona de Habitabilidad

PALE RED DOT

- *Proxima b* es nuestro vecino
- Oportunidad sin igual para su estudio

- Al alcance de sondas de exploracion interestelar

nature

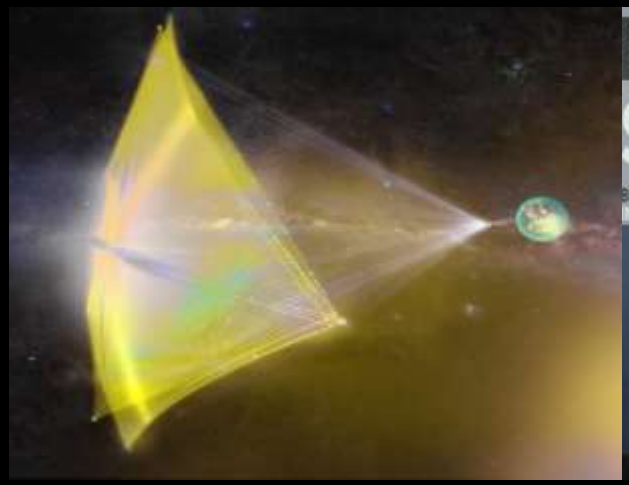
THE INTERNATIONAL WEEKLY JOURNAL OF SCIENCE

NEAR HORIZON

A warm terrestrial planet in orbit around Proxima Centauri, closest star to the Sun PAGES 408 & 437

NATURE.COM/NATURE
25 August 2016 £10
Vol. 536, No. 7617

BREAKTHROUGH STARSHOT



Breakthrough Initiatives: STARSHOT

BOARD

The Board of Breakthrough Starshot program consists of:

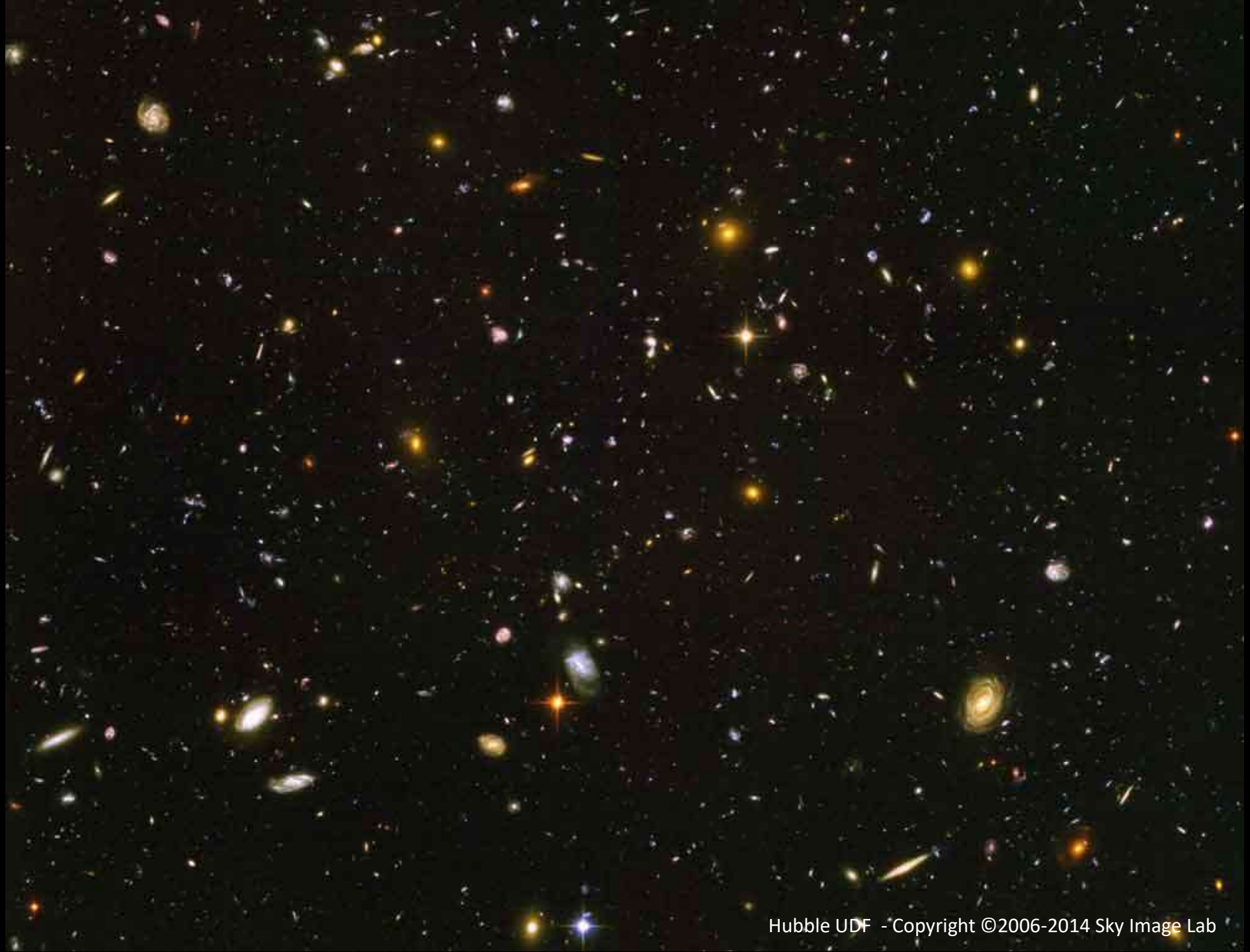
Stephen Hawking

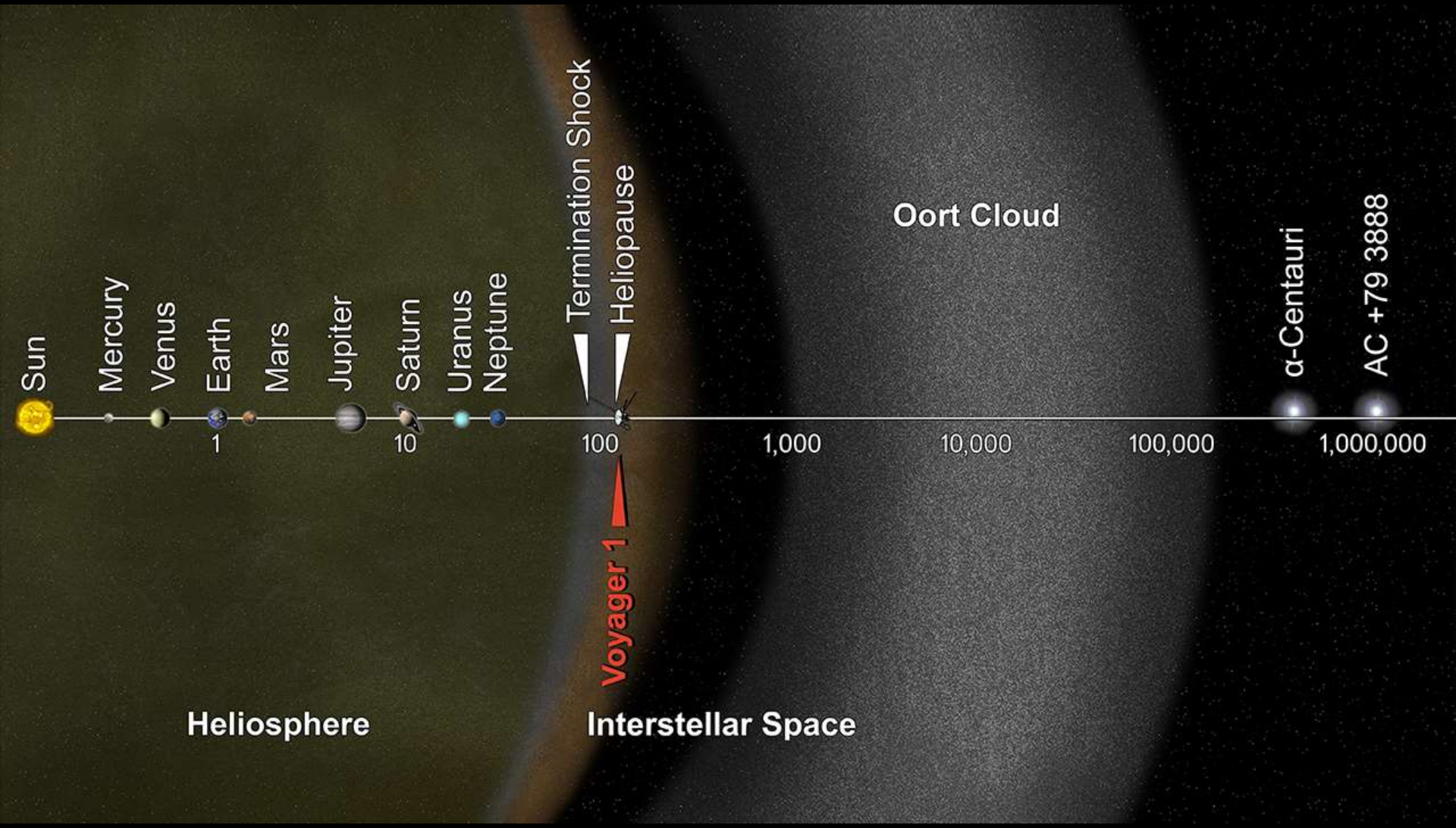
Yuri Milner, founder of DST Global

Mark Zuckerberg, founder and CEO of Facebook

STARSHOT

STARSHOT: en curso hacia Proxima


Hubble UDF - Copyright ©2006-2014 Sky Image Lab

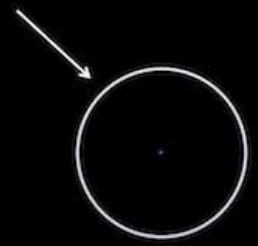

Sun
Mercury
Venus
Earth
Mars
Jupiter
Saturn
Uranus
Neptune
Termination Shock
Heliopause
Oort Cloud
α-Centauri
AC +79 3888
1
10
100
1,000
10,000
100,000
1,000,000
Voyager 1
Heliosphere
Interstellar Space

Un punto azul pálido

Un punto azul pálido

Un punto azul pálido

A Pale Blue Dot



"From this distant vantage point, the Earth might not seem of particular interest. But for us, it's different. Look again at that dot. That's here, that's home, that's us". – Carl Sagan

Credit: PHL @ UPR Arecibo (phl.upra.edu) and NASA

¡Gracias!